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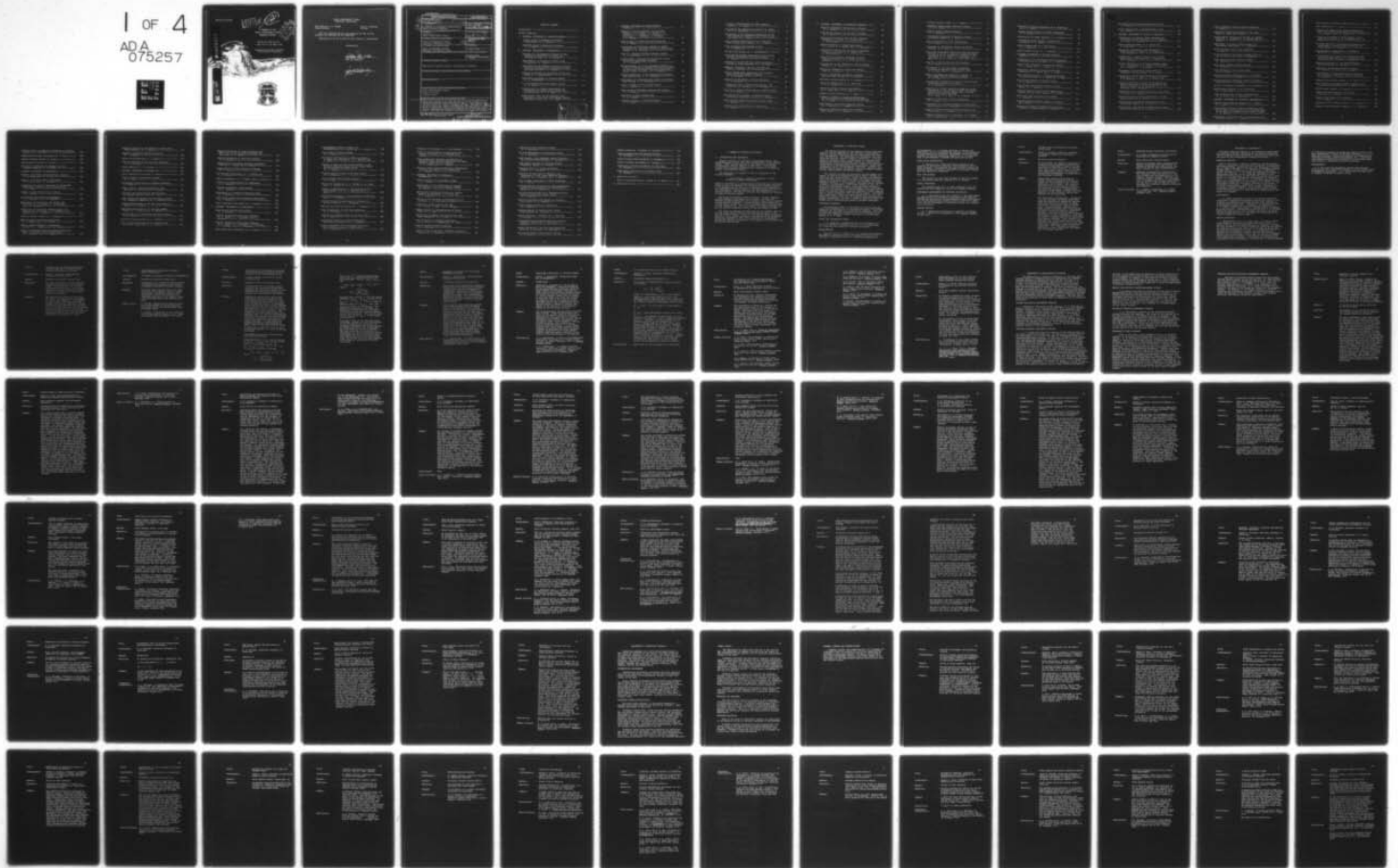
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NAVAL POSTGRADUATE SCHOOL
RESEARCH PROGRAM

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NAVAL POSTGRADUATE SCHOOL
Monterey, California


Rear Admiral T. F. Dedman
Superintendent

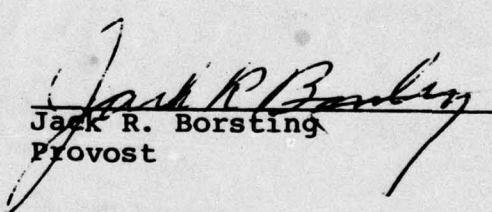
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TABLE OF CONTENTS

Introduction -----	i
Project Summaries:	
1. CHAIRMAN, DEPARTMENT OF COMPUTER SCIENCE-----	1
Integer Linear Programming and Network Optimization (G. H. Bradley)-----	3
SPOTLIGHT Signal Processing and Display (G. A. Rahe)-----	4
2. CHAIRMAN, DEPARTMENT OF MATHEMATICS-----	5
Routines for the Numerical Solution of Some Problems in Lanchester War Gaming and Differential Games (F. D. Faulkner)-----	7
Approximation of Surfaces by Smooth Local Interpolants (R. Franke)-----	8
Convergence of the Method of Parallel Displace- ments for Unconstrained Minimization in the Non-Quadratic Case (I. B. Russak)-----	9
Analysis of Methods for Estimating Reliability Bounds (A. L. Schoenstadt)-----	11
Geostrophic Adjustment in Discrete Models (A. L. Schoenstadt)-----	12
On a Generalization of the Lambert Series (D. H. Trahan)-----	13
Continuation of a General Methodology for Forecasting the Technological Threat from the Soviet Navy (P. C. C. Wang)-----	14
Modernization Plan for the Technical Data Department of the Naval Ships Weapon Systems Engineering Station (P. C. C. Wang)-----	16

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3. CHAIRMAN, DEPARTMENT OF ADMINISTRATIVE SCIENCES-----	17
Research in Officer Manpower and Personnel Planning (E. A. Alden, J. K. Arima, P. M. Carrick, K. T. Marshall, L. Paringer, M. G. Sovereign, R. A. Weitzman, P. R. Milch, P. A. Jacobs)-----	20
Effectiveness of Advertising and Promotions (J. K. Arima)-----	21
Utilization and Technology Transfer of RDT&E Investment for the Naval Facilities Engineering Command (J. W. Creighton)-----	23
Study of a Tethered Balloon Transport System (J. W. Creighton)-----	25
Effectiveness, Selection and Evaluation of Navy Exploratory Development Programs (J. W. Creighton)-----	26
The Development of a Fully Automated Procedure to Produce a Technology Transfer Directory of People to Facilitate the Linker Function in the Technology Transfer Process (J. W. Creighton)-----	27
Systems Acquisition in Navy Research and Development Laboratories (J. W. Creighton)-----	28
Development of a Management and Executive Development Program (J. W. Creighton)-----	30
Detail to NPRDC's OP-01 Liaison Office (R. S. Elster)-----	31
Human Resource Management Research and Support (C. K. Eoyang)-----	32
Regulation of Naval Shipbuilding (J. M. Fremgen)-----	33
Aerospace Industry - DoD Relationship (C. R. Jones)-----	34

A Study of Alternatives for VSTOL Computer Systems (C. R. Jones)-----	35
Navy Center for Acquisition Research (R. Judson and M. G. Sovereign)-----	36
An Analysis of the Conceptual Foundation of the Cost Accounting Standards Board's Cost Alloca- tion Model (S. S. Liao)-----	38
Rate of Return Determination for a Regulated Naval Shipbuilding Industry (S. S. Liao)-----	39
Stock Migration from NAVELEX to SPCC (A. W. McMasters)-----	40
Software Engineering (N. F. Schneidewind)-----	41
Relationships Between Psychological Test Scores, Academic Achievement and Career Success (J. Senger)-----	43
Aggregation of Enlisted Pay Grades and Service Ratings by Tasks Performed (R. A. Weitzman)-----	46
Manpower, Personnel, Training, and Material Resource Interfaces (R. A. Weitzman)-----	47
Officer Subspecialty Aggregation for Personnel Substitution and Manpower Planning (R. A. Weitzman)-----	48
Reduction of Shrinkage in Pattern Analysis (R. A. Weitzman)-----	49
A Sequential Test of Strong Inequalities: The Prediction of Presidents (R. A. Weitzman)-----	50
Test Bias: Better Cutting Scores or Better Tests? (R. A. Weitzman)-----	51
Navy Health Care Systems: Professional/Para- professional Personnel Mix Study (D. Whipple)-----	52
Naval Officer Career and Quality of Life Study (D. Whipple)-----	53
Estimation of Average Cost Per Beneficiary (D. Whipple)-----	54

4. CHAIRMAN, DEPARTMENT OF OPERATIONS RESEARCH-----	55
Tactical Development and Evaluation Program (A. F. Andrus)-----	58
Statistical Analysis for the TPQ-27 Program (D. R. Barr)-----	59
Statistical Procedures for the Joint Analysis Program (D. R. Barr, H. J. Larson, and T. Jayachandran)-----	60
ACCAT Experiments in Command and Control (D. R. Barr, G. K. Poock, and F. R. Richards)----	61
Statistical Analysis for the Joint Oil Analysis Program (D. R. Barr, H. J. Larson, and T. Jayachandran)-----	62
Exploitation of Special Structure in Large Scale Optimization (G. G. Brown and G. H. Bradley)-----	63
Availability in the Presence of a Finite Spares Backlog (J. D. Esary)-----	64
Reliability Aspects of a Fleet Air Defense Study (J. D. Esary)-----	65
Tactical Implication of Magnetic Airborne Detector (MAD) Systems (R. N. Forrest)-----	66
FBM Effectiveness Studies (R. N. Forrest)-----	67
Simulation Methodology (D. P. Gaver and P. A. W. Lewis)-----	68
Stochastic Systems Analysis and Modeling (D. P. Gaver and P. A. W. Lewis)-----	69
Computer System Modeling (D. P. Gaver)-----	71
Probability Modeling, Numerical Methodology and Data Analysis for Communications Networks (D. P. Gaver)-----	72
NTDS Computer Facilities Scheduling System (J. K. Hartman, G. T. Howard)-----	73
Models for Determining Munitions Stockpile Requirements (J. K. Hartman)-----	74

A Target Selection Model (G. T. Howard)-----	75
LLRANDOMII Random Number Generator Package (P. A. W. Lewis)-----	76
Aircraft Carrier Landing Patterns (K. T. Marshall)-----	77
A Quantitative Analysis of Political Unrest in Eastern Europe (P. R. Milch)-----	78
Design Parameters in Color CRT Displays (D. E. Neil)-----	79
Conference on Occupational Safety and Health Analysis (D. E. Neil)-----	80
Case Study Development Concerning Ship Acquisition Process in the U. S. Navy as it Relates to Both the Executive and Legislative Branches of the Government (J. F. Owens, J. D. Buttinger, S. M. Dean)-----	81
Analysis of XM1 Battlefield Effectiveness (S. H. Parry)-----	82
Development of the Simulation of Tactical Alternative Responses (STAR) Combat Model (S. H. Parry and J. K. Hartman)-----	84
Model Development and Analysis in Support of Army Combat Vehicle Technology Program (S. H. Parry)-----	87
A Preliminary Evaluation of Three Alternative Navy Shipbuilding Industry Structures (C. A. Peterson)-----	88
Definition of Initial Operating Capabilities and Experiments in the Advanced Command and Control Architectural Testbed (ACCAT) and in the NPS Remote Site Module (NPS-RSM) (G. K. Poock, D. R. Barr, F. R. Richards)-----	89
Asymptotic Efficiency of Point Estimators (R. R. Read)-----	90
Development of a Software Package for Exploratory Data Analysis (F. R. Richards)-----	91
Computer Assisted Target Positional Analysis for P3 Aircraft (R. H. Shudde)-----	92
Aerospace Industry (M. G. Sovereign, C. R. Jones, and T. Jayachandran)-----	93

Maintenance System Development (M. G. Sovereign and J. D. Esary)-----	94
Lanchester-Type Models of Warfare (Monograph) (J. G. Taylor)-----	95
Optimization of Combat Dynamics (J. G. Taylor)-----	96
Instrumental Range Studies - Torpedo Path Estimation (J. B. Tysver)-----	99
Search Evasion Game in a Fixed Region (A. R. Washburn)-----	100
Range Studies Project (A. R. Washburn)-----	101
5. CHAIRMAN, DEPARTMENT OF NATIONAL SECURITY AFFAIRS-----	102
Perceptions of the Superpower Military Balances: Considerations and Evidence (D. C. Daniel)-----	104
Soviet Naval Operations and Exercise Analysis (D. C. Daniel and W. C. Reese)-----	105
Comparative Analyses of Major Soviet Fleet Exercises (D. C. Daniel and W. C. Reese)-----	106
Arab Political Elites: A Preliminary Analysis of Selected Elites (R. H. Magnus and J. Amos)-----	107
The Military Balance in Southern Africa (B. M. Schutz)-----	108
Data Analysis and National Security Policy- Making (R. G. Sherwin)-----	110
Lethality Tests of Air Force Gun Ammunitions Against Arrival Target Arrays (R. H. Stolfi)-----	112
The Soviet-Cuban Intervention in Angola (J. Valenta)-----	113
Eurocommunism and Eastern Europe (J. Valenta and D. Burke)-----	114
Bureaucratic Politics Paradigm and the Soviet Invasion of Czechoslovakia (J. Valenta)-----	116

The USSR and the Somalian-Ethiopian Conflict (J. Valenta)-----	117
Soviet Intervention in Czechoslovakia, 1968 (J. Valenta)-----	119
6. CHAIRMAN, DEPARTMENT OF PHYSICS & CHEMISTRY-----	120
Investigation of Nuclear Giant Resonances by Inelastic Electron Scattering (F. R. Buskirk, J. N. Dyer, R. Pitthan)-----	124
Laser Produced Plasmas (A. W. Cooper and F. Schwirzke)-----	126
Generation, Propagation, and Detection of Flexural Waves in Beams (A. B. Coppens and O. B. Wilson)-----	127
Transmission of Acoustic Energy from a Fluid Wedge into a Fast Bottom (A. B. Coppens and J. V. Sanders)-----	128
Optical Extinction in the Marine Boundary Layer (E. C. Crittenden, A. W. Cooper, E. A. Milne, G. W. Rodeback, R. L. Armstead)-----	131
Development of Ray-Tracing Algorithms for Underwater Acoustic Ranges (H. A. Dahl)-----	133
Evaluation of Noise Characteristics of Pneumatic Hand Tools (H. A. Dahl, J. V. Sanders, and K. E. Woehler)-----	135
Classical Trajectory Studies of Low Energy Ion Impact Mechanisms on Clean and Reacted Single Crystal Surfaces (D. E. Harrison, Jr., B. J. Garrison, and N. Winograd)-----	136
Geomagnetic Field Fluctuations on the Ocean Floor (O. Heinz and P. Moose)-----	139
Spectroscopic Data Center Compilation of Atomic Energy Levels (R. L. Kelly)-----	140
Spectroscopic Data Center Compilation of Near Ultraviolet Spectra (R. L. Kelly)-----	141
Spectroscopic Data Center Compilations of Vacuum Ultraviolet Spectra (R. L. Kelly)-----	142

Ocean Parameters Affecting Sonar Propagation (H. Medwin)-----	143
Geomagnetic Field Fluctuations on the Ocean Floor (P. Moose and O. Heinz)-----	145
Thermochemical Calculations Related to Internal Blast (R. A. Reinhardt, G. F. Kinney, and K. J. Graham)-----	146
Measurement of Acoustic Source Levels in a Reverberant Environment (J. V. Sanders)-----	147
Marine Boundary Layer Study: MABLES-WC (G. Schacher)-----	148
At Sea Studies of the Marine Boundary Layer in the Los Angeles Air Basin (G. Schacher)-----	149
Laser Induced Acoustic Pulses in Water (F. Schwirzke)-----	150
LISA, Laser Induced Surface Analysis (F. Schwirzke)-----	151
Light Trapping in Thin Liquid Films (W. M. Tolles)-----	154
Non-Line-of-Sight Communication in the Middle Ultraviolet (W. M. Tolles)-----	155
The Scattering of Spherical Pulses by Slightly Rough Surfaces (I. Tolstoy)-----	157
Acoustic Transducer Development (O. B. Wilson)-----	158
Range Studies Program (O. B. Wilson and D. B. Hoisington)-----	159
X-Ray Emission from a Laser-Initiated Pinch (K. E. Woehler and F. Schwirzke)-----	160
7. CHAIRMAN, DEPARTMENT OF ELECTRICAL ENGINEERING-----	162
Computer Algorithms and Display (M. L. Cotton, H. J. Rood)-----	167
Investigation of Toxic (Known or Potential) Air- borne Vapor Concentrations in Various Work Areas of the Naval Air Rework Facility, North Island (J. H. Duffin)-----	168
Correlation of Work Area Vapor Concentrations with Production Rates (J. H. Duffin)-----	169

Applications of Charge Transfer Devices (T.F. Tao)---	170
VLSI Technology (T. F. Tao)-----	172
Analysis and Design of the Control Systems for the C.A.B. Type Surface Effect Ship (A. Gerba, Jr., G. J. Thaler, and D. M. Layton)-----	174
A Study of the Effect of Click Jammers on U.S. Navy Radar Systems (D. B. Hoisington and J. B. Knorr)-----	175
An Investigation of Intermodulation Products and Proper Ways to Specify Them in Wide Band HF Multicouplers (S. Jauregui)-----	176
Electromagnetic Compatibility of Composite Materials (S. Jauregui)-----	177
An Investigation of Task Force Information and Timeliness Requirements for Tactical Over-the- Horizon Missile Launching (S. Jauregui)-----	178
Computer Simulation of the BULLDOG/BULLSEYE Wide Band System (S. Jauregui)-----	179
Modulation, Propagation and Noise Studies (S. Jauregui, G. Myers, and J. Knorr)-----	180
Investigation of Horizontal-Vertical Polariza- tion Effects on HFDF Small Aperture Antennas (S. Jauregui)-----	181
Communications System Studies (J. B. Knorr)-----	182
Naval Electronics Systems Command Research Chair in Electrical Engineering (G. R. Myers)-----	183
SATCOM Signal Analyzer (J. Ohlson)-----	185
Discrete Signal Processing and Digital Filtering (S. R. Parker)-----	186
Reduced Order Models for Simulation (S. R. Parker)-----	188
Techniques of RF Signal Analysis (J. P. Powers)-----	189
Computer Aided Acoustical Imaging (J. P. Powers)-----	190

Acoustic Arrays and Adaptive Processing of Acoustic Signals (D. A. Stentz)-----	192
Sampled Analog Signal Processing (T. F. Tao)-----	194
Torpedo Tracking Studies (H. Titus)-----	197
EA-6B Mission Planning (H. Titus)-----	198
Evaluation, Simulation and Analysis for the Crossbow Committee (H. A. Titus)-----	199
8. CHAIRMAN, DEPARTMENT OF METEOROLOGY-----	200
Tropical Large-Scale Atmosphere-Ocean Coupling (C.-P. Chang and K. M. W. Lau)-----	202
Dynamics of Tropical Waves and Monsoons (C.-P. Chang and R. T. Williams)-----	203
Interannual and Spatial Variations of Sea-Surface Temperature, Tropical Waves and Mean Flows (C.-P. Chang)-----	205
Studies of Large-Scale Tropical Motions (C.-P. Chang)-----	207
Fog Dynamics and San Nicolas Assessment (K. L. Davidson and G. E. Schacher)-----	208
Measurement of Evaporation Duct Height Over The Ocean (K. L. Davidson, T. M. Houlihan, and G. E. Schacher)-----	209
Interaction of the Oceanic Boundary Layer with Large-Scale Circulations (R. L. Elsberry, R. W. Garwood, and R. L. Haney)-----	210
Tropical Cyclone Studies (R. L. Elsberry)-----	211
Modeling Upper Ocean Thermal Structure (R. L. Elsberry and R. W. Garwood, Jr.)-----	213
Oceanic Thermal Response to Atmospheric Forcing (R. L. Elsberry and R. W. Garwood, Jr.)----	214
Tests of a Mesoscale Numerical Weather Prediction Model Over Europe and the United States (G. J. Haltiner and R. A. Anthes)-----	216

Numerical Studies of the Dynamics of Large Scale Ocean Anomalies (R. L. Haney)-----	217
Mesoscale Atmospheric Events--Antarctica (R. J. Renard)-----	218
Marine Fog Forecasting (R. J. Renard)-----	220
Numerical Modeling of Air Flow Over Mountains (R. T. Williams)-----	223
Global Modeling (R. T. Williams)-----	224
9. CHAIRMAN, DEPARTMENT OF AERONAUTICS-----	225
Axial Compressor Flow Fields (D. Adler)-----	229
Aircraft Combat Survivability Studies (R. E. Ball)-----	230
Aerodynamic Stabilization of Gaseous Discharges (O. Biblarz)-----	232
Study of Marks' Electrothermodynamic (ETD) Generator (O. Biblarz and T. H. Gawain)-----	233
Electrode Loss Mechanisms in MHD Generators (O. Biblarz and R. E. Ball)-----	234
Laser Doppler Velocimeter and Holographic Studies of a Transonic Compressor (D. J. Collins)-----	235
A Basic Reformulation of the Pipe Flow Stability Problem (T. H. Gawain)-----	236
Operating Characteristics of the Dual Chamber Rocket (T. H. Gawain and D. W. Netzer)-----	237
Surface Effect Ship Technology Testcraft Program (D. M. Layton)-----	239
Aircraft Fatigue Studies (G. H. Lindsey)-----	240
Use of Sulphur-Hexafluoride as a Leak Detector for Buried Steam Lines (J. A. Miller)-----	241

Emission Levels and Air Quality Effects from Naval Air Station Aircraft Operations and Test Cells (D. W. Netzer)-----	242
Interior Ballistics of Solid Fuel Ramjets (D. W. Netzer)-----	245
Investigation of Unsteady Transonic Compressor Flows (M. F. Platzter and K. Vogeler)-----	247
Investigation of VSTOL Propulsion Problems (M. F. Platzter)-----	248
CCR Unsteady Aerodynamics (L. V. Schmidt and J. A. Miller)-----	250
VSTOL Aerodynamics (L. V. Schmidt and R. W. Bell)----	252
Velocity Field Measurements in Compressors (R. P. Shreeve)-----	253
Transonic Compressor Investigations (R. P. Shreeve)-----	254
Development of a Transonic Compressor Model (R. P. Shreeve)-----	256
Small Turbine Blade Row Performance Measurements (R. P. Shreeve)-----	257
Axial Compressor Flow Fields (R. P. Shreeve)-----	258
10. CHAIRMAN, DEPARTMENT OF OCEANOGRAPHY-----	259
Earth Physics Program Requirements (R. S. Andrews)-----	263
Acoustic Variability and Air-Sea Transfer (W. W. Denner, K. L. Davidson, and T. P. Stanton)-----	264
Acoustic Variability and Air-Sea Exchange (W. W. Denner, K. L. Davidson, T. M. Houlihan, J. V. Sanders, and E. B. Thornton)-----	266
Sonic Mixed Layer Experiment (W. W. Denner)-----	268

Oceanographic Studies in Support of COMOCEANSYSPAC (W. W. Denner and J. H. Jung)-----	269
Arctic Chair in Marine Science (W. W. Denner)-----	270
Biological Contributions to Shoreline Erosion in Santa Cruz, California (E. C. Haderlie and G. Clark)-----	272
Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters Off the Central California Coast (E. C. Haderlie)-----	273
Biodeterioration Studies in Monterey Harbor (E. C. Haderlie)-----	274
Low Wavenumber Ocean Energy Transport (G. H. Jung)-----	275
Marine Fog Forecasting (D. F. Leipper, G. H. Jung, and R. J. Renard)-----	277
Studies of Finestructure in the Marginal Sea-Ice Zone--MIZPAC 77-78 (R. G. Paquette and R. H. Bourke)-----	279
Vertical Datum Planes in the Ocean/River Transition Zone (W. C. Thompson)-----	281
Undersea Acoustic Surveillance of Offshore Oil and Gas Platforms (W. C. Thompson)-----	282
Monterey Bay Ocean Wave Study (W. C. Thompson)-----	283
Field Measurements of Surf Zone Energetics (E. B. Thornton)-----	284
Kinematics of Breaking Waves in the Surf Zone (E. B. Thornton)-----	286
Biochemical Modelling of Marine Ecosystems and Acoustic Prediction (E. D. Traganza)-----	288
Chemical Mesoscale and ATP-Biomass Correlated with Satellite Imagery of Ocean Fronts (E. D. Traganza)-----	290

Dynamics of the Oceans (J. J. von Schwind)-----	291
Study of the California Countercurrent Off Central California (J. B. Wickham and S. P. Tucker)-----	292
Three Dimensional Structure and Behavior of Mesoscale Ocean Features Associated with Their Remotely Sensed Surface Signature (J. B. Wickham and S. P. Tucker)-----	293
Satellite Ocean Surface Temperature Observations of Fronts and Eddies (J. B. Wickham and S. P. Tucker)-----	294
11. CHAIRMAN, DEPARTMENT OF MECHANICAL ENGINEERING-----	295
Lateral Buckling of Nonprismatic Beams (J. E. Brock)-----	300
Improvements in the Predictions of Stresses and Strains in the Finite Element Method (G. Cantin)-----	302
Self-Filtering Infrared Detector for Missile Seekers (R. Fantauzzo, A. E. Fuhs, and R. B. Schooler)-----	303
Melting of Ice Subjected to Turbulent Flow of Sea Water (A. E. Fuhs and R. Stolfi)-----	304
Holographic Nondestructive Test NDT (A. E. Fuhs, P. Huber, and P. Hoffman)-----	306
Shaped Charges for Neutralization of Buried Mines (A. E. Fuhs)-----	308
Aero-optics; Boundary Layer Control for Laser Beam Propagation (A. E. Fuhs)-----	310
Land Contouring to Optimize Wind Power (A. E. Fuhs, G. N. Vanderplaats, S. Fuhs)-----	311
Marine Propulsion Control Analysis (T. M. Houlihan)-----	312
Study of Digital Electronic Automatic Combustion Controls (T. M. Houlihan)-----	313

Simulation of LHA Propulsion System (T. M. Houlihan)-----	314
Hot Wire Measurement at San Nicolas Island (T. M. Houlihan)-----	315
Heat Transfer, Heat Exchanger Design, Corrosion and Biofouling Hydrodynamics (M. Kelleher)-----	316
Inter-Agency Agreement to Provide Project Management Support (M. Kelleher)-----	317
Secondary Flow in a Curved Rectangular Channel (M. D. Kelleher)-----	319
Stability of Pipe Flows of Newtonian and Viscoelastic Fluids Using Chebyshev Expansion Functions (M. D. Kelleher and R. J. Hansen)-----	320
Heat Transfer Enhancement in Naval Condensers (P. J. Marto)-----	321
Thermomechanical Processing of Aluminum-Magnesium Alloys Containing High Weight Percentages of Magnesium (T. R. McNelley)-----	323
Ballistic Characteristics of Thermomechanically- Processed Ultra-High Carbon Steels (T. R. McNelley)-----	325
Effects of Multiple Weld Repairs on Aluminum Alloy 5083-0 (T. R. McNelley)-----	327
Finite Element Analysis of Cavitation (R. E. Newton)-----	328
Advanced Methods in Computational Thermo- fluid Dynamics (R. H. Nunn)-----	329
Energy Conversion - Fluidyne (R. H. Nunn and D. Salinas)-----	330
Integrated Cost/Performance Analysis of Marine Propulsion Systems (R. H. Nunn and M. D. Kelleher)-----	331
Analog Simulation of the LHA Steam Generating Plant (R. H. Nunn and T. M. Houlihan)-----	332
Gas Turbine Exhaust Stack Eductor Systems (P. F. Pucci)-----	333

Energy Conversion - Fluidyne (D. Salinas)-----	334
Advanced Composites Fire Response Program (D. Salinas)-----	335
Vortex-Induced Cable Strumming (T. Sarpkaya)-----	336
Fluidic Concepts Development (T. Sarpkaya)-----	338
Prediction of Forces and Moments at High Alpha (T. Sarpkaya)-----	339
Hydroelastic Oscillations in Harmonic Flow (T. Sarpkaya)-----	341
12. Additional Projects	
Missile System Reliability Program (W. M. Woods)-----	343
13. Distribution List-----	344

A SUMMARY OF RESEARCH ACTIVITIES

1. INTRODUCTION AND BACKGROUND

Research activity at the Naval Postgraduate School (NPS) performed during fiscal year 1978 is abstracted in this summary volume. These results are due to the efforts of principal investigators (faculty members at NPS) with, in most cases, student contributions through activity leading to a thesis in pursuit of an advanced degree.

The importance of research at NPS is recognized in the mission statement:

"...to encourage a program of research in order to sustain academic excellence."

Research performed at an educational institution such as NPS provides not only the benefits of original investigations inherent in all research activities, but in addition it contributes to the knowledge base and vitality of the educational activities at the institution. Sponsor benefits include augmentation of research efforts with student activity, and exposure of students to areas of current concern.

The Naval Postgraduate School provides a unique interface between academic institutions and the Navy. As such, the research projects undertaken are in general more clearly related to Navy and DOD interests. A substantially larger fraction of the R&D effort at NPS is in the 6.2 category than would be found in most universities. This is a result of student interests as well as faculty interests created by the environment at NPS.

The level of research performed during the academic year at NPS has risen almost linearly over the past 20 years to the current level of effort. Prior to this period there was minimal activity. Such growth represents a maturation of the graduate educational process at NPS, and a provision of professional activities clearly contributing to the quality of the faculty and the educational process.

DEPARTMENT OF COMPUTER SCIENCE

The research program of the Computer Science Department supports and is supported by both the Naval Postgraduate School's Computer Facilities and the department's own extensive laboratories. The department has cognizance over the Naval Postgraduate School's Computer Laboratory. A rapidly expanding research effort includes work in: hardware and software performance measurement methods and applications; optimization theory and applications; compiler and operating system design, implementation and optimization; coding and information theory; microcomputer structures, software, and systems design; signal processing; computer graphics; design of real time systems; and digital filters.

The research program has permitted the development of a number of functional laboratories which support further research as well as instruction. These include a microelectronics laboratory where microprocessors and single board computers are interfaced with a variety of equipment to become imbedded computers; a microcomputer laboratory which includes a number of microcomputer development systems as well as a multi-user development system; a multiprocessor emulation facility consisting of a microprogrammable multi-interpreter system for the emulation of various computer systems; and the Naval Postgraduate School Computer Laboratory, which supports work in signal processing and interactive graphs. The laboratory boasts both a multi-processor system with an array processor and analog front end, to support signal processing and pattern recognition, and also a graphics capability which includes each of the principal types of graphics terminals.

INTERACTIVE GRAPHICS

The principal effort in the Graphics area has been the design and implementation of software interfaces and language extension for the support of interactive graphics. This work provided the necessary foundation for the mechanization of certain anti-submarine warfare programs on a storage tube display by G. A. Rahe.

CODING AND INFORMATION THEORY

R. W. Hamming is responsible for many fundamental results in coding and information theory. He is continuing this research and preparing a book on the subject.

MICROCOMPUTERS

The work of U. R. Kodres and G. A. Kildall has made this department a recognized center of expertise which has contributed to Navy-wide efforts to formulate standards for

microcomputers. U. R. Kodres continues to explore the application of the interconnected networks of microcomputers. A multi-terminal microcomputer development system has been acquired to provide continuing support for G. A. Kildall's work in microcomputer languages and operating systems.

LARGE SCALE OPTIMIZATION

G. Bradley and G. Brown are doing research on the solution of large scale networks, linear programs and integer programs. The research has been applied to major DOD projects including material distribution, personnel assignment and ammunition production.

REAL TIME SYSTEMS

The analysis of real time systems by data flow graphs is a continuing research interest of U. R. Kodres.

SIGNAL PROCESSING

The research area of G. A. Rahe continues to be concerned with anti-submarine warfare and computer graphics.

PERFORMANCE MEASUREMENT AND SOFTWARE RELIABILITY

N. F. Schneidewind has done research on the development and application of performance measurement techniques including the analysis of multiprogrammed computer performance; the relationship between program structure and error detection; and the development of stochastic models for software error prediction.

DIGITAL FILTERS

R. W. Hamming has continued his research on digital filters. During 1977 he published a book Digital Filters on this work.

Title: Integer Linear Programming and Network Optimization

Investigator: Gordon H. Bradley, Associate Professor of Computer Science and Operations Research

Sponsor: National Science Foundation

Objective: To investigate the algebraic structure of integer linear programming problems and to develop algorithms to compute optimal solutions to these problems. To investigate algorithms to solve large scale network optimization models including the capacitated transshipment, transportation and assignment problems.

Summary: Fixed order enumeration methods for integer linear programming problems are simple and often effective for solving practical size problems. This class of algorithms can be improved by studying the structure of the enumeration path as the algorithm proceeds. Computational testing of these ideas has shown that this approach can significantly improve performance of the algorithms.

The capacitated transshipment, transportation and assignment problems model many important defense and commercial applications including the transport of goods, assignment of personnel, and bid evaluation. Data structures, algebraic and graph theoretic methods were investigated for the efficient solution of large-scale problems. For these network models an extremely efficient algorithm was developed. The results of this investigation were used to develop a FORTRAN program for capacitated pure network problems. Test results with problems with 10,000 nodes and 35,000 arcs show that the program is as much as 50 times faster than commercial linear programming algorithms. The copyrighted program is available to other researchers and Department of Defense agencies.

Title: SPOTLIGHT Signal Processing and Display

Investigator: G. A. Rahe, Professor of Electrical Engineering and Computer Science

Sponsor: Naval Electronic Systems Command

Objective: Design and develop signal processing and display algorithms with application to ASW and to design test and evaluate computer systems for their mechanization.

Summary: Research on man-machine interfaces for NPS SPOTLIGHT signal processing and display systems has continued during FY 78; however, computer system design has dominated this year's efforts. An investigation of hardware and software requirements for the use of a CSP Inc Map 300 array processor on contractor supplied algorithms was completed.

Thesis Directed: G. T. Vrabel, "Evaluation of a Signal Processing Test Bed", Master's Thesis, December 1978.

DEPARTMENT OF MATHEMATICS

The major areas of research in the Mathematics Department are Numerical Analysis, Optimization and Applied Statistics. A brief summary of the activities in each field is given and then some of the miscellaneous research activities.

NUMERICAL ANALYSIS

Most of the work in numerical methods is directed toward efficient computation, particularly of problems in meteorology and related fields, coordinated with the Department of Meteorology, NEPRF, and FNWC. F. D. Faulkner is analyzing Fourier coefficients as a time series with the view of improving weather forecasting. F. H. Franke has developed a program to approximate functions of two variables smoothly by local methods of interpolation at scattered data points and is comparing it with other schemes for interpolation of scattered data. A. L. Schoenstadt with R. T. Williams, Meteorology, is continuing investigation of the effects of the choice of discretization scheme and grid point location on the process of geostrophic adjustment. Schoenstadt is also working with S. Parry, Operations Research, and a student, designing and programming computer models to evaluate the impact of electronic warfare against U.S. Army tactical communications and electronic systems.

OPTIMIZATION

I. B. Russak continues his work in obtaining sufficient conditions to guarantee convergence and certain rates of convergence for numerical algorithms dealing with problems in unconstrained optimization. Faulkner is continuing his work on differential games and on Lanchester war gaming with J. G. Taylor, Operations Research, working mainly on programming and solution. Schoenstadt is working with T. M. Houlihan, Mechanical Engineering, and a student, designing and implementing optimal controls for the model of a naval boiler in a Marine Propulsion Control Model.

APPLIED STATISTICS

T. Jayachandran, with D. R. Barr and J. H. Larson, Operations Research, has been developing statistical tests to monitor the tri-service spectrometric oil analysis, to study the wear condition of aircraft engines by examining lubricating oil samples; statistical tests are to be used to ensure that minimum testing standards are met. T. Jayachandran and M. G. Sovereign are developing a formal model to describe the behavior of the aerospace industry and the DoD in the weapons-system acquisition process, to be used in analyzing alternative acquisition procedures. Jayachandran is working on an occupational safety assessment, to assist ONR in the development

of statistical analyses to assess the impact of OSHA on the Navy, especially in regard to asbestos insulation. P. C. C. Wang has continued in developing methods for analyzing and forecasting threats, weapons development, etc., and associated graphical methods for representing multivariable data, particularly in representing national policies.

MISCELLANEOUS

M. D. Weir has been developing various instructional materials for PSI, especially computer oriented courses using programmable calculators. D. H. Trahan has continued work in complex variables on Lambert series.

Title: Routines for the Numerical Solution of Some Problems in Lanchester War Gaming and Differential Games

Investigator: Frank D. Faulkner, Distinguished Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To make up routines for the numerical solution of problems in differential games. In particular: (1) to find solutions which dominate equilibrium solutions to some differential games, and (2) to develop solutions in Lanchester war gaming.

Summary: For equilibrium games a routine has been made up and partially programmed to effect the solutions. Programming is continuing. For Lanchester war gaming, difficulties have been encountered with the conditions for a corner. At a corner the controls and the Lagrange multipliers may all be discontinuous and I have not been able to work out the associated conditions, when the parameters of an extremal are varied.

Title: Approximation of Surfaces by Smooth Local Interpolants

Investigator: R. Franke, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: Development of a method of smooth surface interpolation at scattered data points including a documented computer program.

Summary: Proposed method was developed and implemented on the computer, and the results documented. Perspective plots of the generated surfaces are displayed for comparison purposes in the report, which also describes use of the computer program.

Publications: R. Franke, "Smooth Surface Approximation by a Local Method of Interpolation at Scattered Points", Technical Report NPS 53-78-002, 1978.

R. Franke, "Reproducing Kernel Functions for the Sard Corner Spaces $B_{[p,q]}$ ", Technical Report NPS 53-78-001, $[p,q]$ 1978.

Title: Convergence of the Method of Parallel Displacements for Unconstrained Minimization in the Non-Quadratic Case

Investigator: I. Bert Russak, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To establish the convergence characteristics of the method of parallel displacements (described below) in the non-quadratic case when using exact derivatives and numerical derivatives.

Summary: Problems in optimization occur very frequently in military applications, e.g. optimizing with respect to time to intercept the parameters of a missile interceptor system. Furthermore, since constrained optimization problems can often be stated in terms of unconstrained ones, then methods for solving the latter are very important. The method of parallel displacements is a powerful tool for solving unconstrained optimization problems and understanding its convergence characteristics is necessary for successful application to actual problems. In describing the method of parallel displacements we shall refer to the function $f(x)$ where:

i) $f(X)$ is of class C^2 , ii) X is an N dimensional vector, iii) $f(X)$ is strictly convex.

The method of parallel displacements will now be described:

Starting with the $N + 1$ initial points $X_{1,1}, X_{1,2}, \dots, X_{1,N+1}$ which do not lie in an $N - 1$ dimensional plane, set $P_1 = X_{1,N+1} - X_{1,1}$. For $j = 1, \dots, N$, let X_{2j} be obtained as follows:

$$X_{2j} = X_{1j} + \alpha_{1j} P_1 \quad j = 1, \dots, N$$

where

$$\alpha_{1j} = \frac{-P_1^T f'(X_{1j})}{P_1^T f''(X_{11}) P_1}$$

with f' , f'' , " T " denoting respectively, the first and second derivatives and the transpose. Set $P_2 = X_{2,N} - X_{2,N-1}$ and

$$X_{3j} = X_{2j} + \alpha_{2j} P_2 \quad j = 1, \dots, N-1$$

where

$$\alpha_{2j} = \frac{-P_2^T f'(X_{2j})}{P_2^T f''(X_{11}) P_2}.$$

Continue this process in the same manner with $P_3 = X_{3,N-1} - X_{3,N-2}$ to get points $X_{4,j}$ $j = 1, \dots, N-2$. After N steps we obtain a point $\bar{X} = X_{N+1,1}$. This completes one cycle of the method. The point \bar{X} so obtained can be shown to provide a minimum for f if f is quadratic with a positive definite Hessian at its minimum point. If f is not quadratic, then we set $X_{1,1} = \bar{X}$ and repeat the procedure.

Principles true in the quadratic case have been extended to prove convergence in the non-quadratic case when: a) assuming a bounded third derivative and b) using exact first and second order derivatives in the iteration method. The step currently in progress is to generalize the above results by proving convergence in the non-quadratic case when using numerical first and second order derivatives and also when dropping the assumption concerning the third derivative.

Title: Analysis of Methods for Estimating Reliability Bounds

Investigator: Arthur L. Schoenstadt, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: This study investigated the accuracy of bounds on the reliability of a system, composed of a serial arrangement of independent, exponential failure law components. The bounds were produced by two well known, but conceptually different methods - the Lieberman-Ross Method and the Mann-Grubbs Method for Type II Censoring. This is a continuing project.

Summary: Both analytic and simulation methods were used to compare the estimated bounds produced by the two methods using identical data. In each instance, whichever method produced the lower upper bound on the hazard rate without producing a false bound was judged superior. It was shown that the Mann-Grubbs method generally produces superior bounds, except when fairly restrictive assumptions were made on the order in which the failure data was recorded. Furthermore, results indicated that an important number of the cases in which the Lieberman-Ross method produced the superior bound were cases that were not attractive from a practical standpoint.

Publication: A. L. Schoenstadt, "A Comparison of the Lieberman-Ross and Mann-Grubbs Methods," submitted to the Journal of the American Statistical Association.

Title: Geostrophic Adjustment in Discrete Models

Investigator: Arthur L. Schoenstadt, Associate Professor of Mathematics

Sponsor: Un-sponsored

Objective: Geostrophic adjustment is the process by which an atmosphere, numerically modeled by the meteorological primitive equations, tends toward the balanced condition between coriolis and pressure gradient forces. The choice of discrete (finite difference or finite element) scheme used can impact on both the speed with which the balance is achieved, and on the numerical noise generated during the adjustment process. The objective of this investigation is to develop analytic methods to predict the effect of the choice of discretization scheme on the adjustment process.

Summary: The one-dimensional shallow water equations were studied. Quasi-discretization (replace of the spatial terms by discrete approximations) was performed for several different grid schemes, and for both second and fourth order finite differences and piecewise linear finite elements. The resulting equations were studied using Fourier transform methods. It was demonstrated that, using these methods and the concepts of amplitude and phase response commonly associated with filter design, several important general insights on the effect of the discretization are possible.

Publications: A. L. Schoenstadt, "A Note on One-Dimensional Geostrophic Adjustment with Finite Differencing", to appear (February 1979) in Monthly Weather Review.

A. L. Schoenstadt, "A Transfer Function Analysis of Numerical Schemes Used to Simulate Geostrophic Adjustment", Technical Report NPS-53-79-001, November 1978.

TITLE: On a Generalization of the Lambert Series

Investigator: Donald H. Trahan, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: - This study is concerned with infinite series of the form

$$G(z) = \sum \frac{a_n z^n}{1 + c_n z^n}$$

where the coefficients a_n and c_n are complex numbers. Generalized Lambert series have some important properties that can be exploited in number theory and the theory of partitions. If α is the radius of convergence of the series

$\sum a_n z^n$ and γ is the radius of convergence of

$\sum c_n z^n$, then some partial results were known

if $\alpha < \gamma$. The purpose of this study is to reconsider the case $\alpha < \gamma$ and to attack the problem if $\alpha \geq \gamma$. Theorem 1 of this study gives the complete solution to the problem for $\alpha < \gamma$. If $\alpha \geq \gamma$ there seems to be very little information available in the literature. Perhaps the problem has been overlooked, but it also seems to be a difficult problem. We answer one of the main objectives of the study by demonstrating that it is impossible to obtain a theorem similar to Theorem 1, if $\alpha \geq \gamma$. Therefore a different approach is required. Several theorems are established for this case and illustrations are given to show how these results can be applied to specific problems.

Publications: Manuscript has been prepared for publication.

Title: Continuation of a General Methodology for Forecasting the Technological Threat from the Soviet Navy

Investigator: Peter C. C. Wang, Associate Professor of Mathematics and National Security Affairs

Sponsor: Naval Intelligence Support Center

Objective: To develop and test a general methodology for forecasting the technological threat from the Soviet and similarly organized navies of the Eurasian Communist countries (via weapons and weapon platforms).

Summary: The methodology is based on a dynamic general structural model of the process of defense material acquisition in the Soviet Union. The outputs of the process of defense material acquisition are weapons and weapons platforms which are the most substantial part of the technological threat. The methodology concentrates on Weapons Performance Characteristics (WPC) and changes in the WPC's to define the relevant acquisition cycles and indicate the directions of future improvement and potential changes.

Publications: P. C. C. Wang, Editor, Graphical Representation of Multivariate Data, Academic Press, December 1978.

Theses Directed: T. R. Bryan, "An Assessment of Present and Future Soviet Naval V/STOL Capabilities", Master's Thesis, 1978.

F. A. Cast, "PRC Strategic Rocket Studies Now and in the Future", Master's Thesis, 1978.

R. E. Cyboron, "PRC Strategic Rocket Studies Now and in the Future", Master's Thesis, 1978.

R.K. Hammes, "A Forecast of Soviet Long Range ASW Aircraft", Master's Thesis, 1978.

G. P. Harper, "PRC Strategic Rocket Studies Now and in the Future", Master's Thesis, 1978.

C. R. Heckert, "The 53 Centimeter Soviet ASW Torpedo", Master's Thesis, 1978.

D. P. Kimball, "A Forecast of Soviet Long Range ASW Aircraft", Master's Thesis, 1978.

D. B. Miller, "The 53 Centimeter Soviet ASW Torpedo", Master's Thesis, 1978.

K. O'Brian, "The PRC Naval Shipyards and Their Communication Networks", Master's Thesis, 1978.

G. J. Ranum, "An Assessment of Present and Future Soviet Naval V/STOL Capabilities", Master's Thesis, 1978.

J. Tennant, "An Assessment of Present and Future Soviet Naval V/STOL Capabilities", Master's Thesis, 1978.

Title: Modernization Plan for the Technical Data Department of the Naval Ships Weapon Systems Engineering Station

Investigator: Peter C. C. Wang, Associate Professor of Mathematics and National Security Affairs

Sponsor: Naval Ship Weapons Systems Engineering Station

Objectives: To develop a methodology which utilizes an intra-organizational structure to coordinate a modernization that requires the acquisition of facilities involving high technology, and to propose a modernization plan based on methodology developed in the above objective for the Technical Data Department of Naval Ship Weapons Systems Engineering Station to reduce technical and organizational risks. To conduct a symposium on automation technology

Summary: As a by-product of this on-going Naval Postgraduate School study on the 1980 requirements for equipment and technology for Naval Ship Weapons Systems Engineering Station, a joint symposium by Naval Postgraduate School and Naval Ship Weapons Systems Engineering Station on Automated Production of Engineering Data and Display of Digitized Engineering Data has been tentatively scheduled on March 1-2, 1979.

Publications:

1. Proceedings of this Second Symposium on Automation Technology shall be published by Academic Press, New York (tentatively to appear by Dec. 1979).
2. P. C. C. Wang, Editor, "Proceedings of the First Symposium on the Automated Production, Storage, Retrieval and Display of Digitized Engineering Data," Vol. I, Western Periodicals, 1977, 373 pages.

DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Administrative Sciences Department is the Naval Postgraduate School's organizational unit responsible for academic programs designed to educate officers and DOD civilians in a variety of functional management specialties. As such, it is a large, multi-disciplinary department with diverse research projects oriented to support the management tasks within the Navy and the Department of Defense. For ease of exposition, the program is classified into the following six areas of concentration: Systems Acquisition Management Research, Manpower/Personnel Management Research, Health Care Delivery Management Research, Technology Transfer Management Research, Management Science Research, and Resource Allocation/Financial Management Research. The past year's focus of the research in these areas is summarized in the following paragraphs.

SYSTEMS ACQUISITION MANAGEMENT RESEARCH

Research in this area is wide ranging. D. N. Burt was engaged in research in the Foreign Military Sales area with emphasis on NATO rationalization, standardization, interoperability and offsets. Research in this area is now focusing on U. S. DOD's ability to predict likely success anticipated in purchasing a system or subsystem developed by a NATO source. A. C. Crosby developed case studies in the military procurement area. C. R. Jones continued his research into the behavior of defense contractors and the implication of the peculiarities of this industry structure for defense contracting. M. B. Kline continued his research in the systems acquisition process. He also performed research studies in maintainability.

MANPOWER/PERSONNEL MANAGEMENT RESEARCH

J. K. Arima continued his research on the effectiveness of the Navy's advertising effort for its recruiting programs and test and development of a culture-free test of learning aptitude for language-handicapped persons. In addition, Professor Arima headed and coordinated the department's participation in a joint effort with the OPERATIONS RESEARCH department on a project to develop a Navy Officer Planning model. Other department participants were Professors Carrick, Elster, Paringer and Weitzman. W. H. Church continued his research in the area of Management Analysis of adherence to, or failure to observe, sound management practices with particular emphasis on the facilitation of the determination of unnecessary stress caused by poor or untutored approaches to managerial effectiveness. J. D. Senger explored the relationship between personality test scores, academic performance, and the career success of Naval Officers. Lynn Paringer continued her research in the area of Identification of the impact of alternative manpower and personnel policies on the management of the Officer Corps. C. K. Eoyang, as the principal investigator, R. Forbes, R. McGonigal, and R. T. Harris worked in the general research area of Human Resources Management.

The goal is the application of Behavioral Sciences techniques to improve organizational effectiveness and increased productivity. R. A. Weitzman, in research on the retention problem, analysed various methods for predicting retention rates. And in manpower planning and personnel management aggregated enlisted ratings according to tasks performed and showed how to apply the same method to Officer's subspecialities.

HEALTH CARE DELIVERY SYSTEMS/MANAGEMENT SCIENCE

L. Paringer continued her research into the health related determinants of work loss and medical care utilization. D. R. Whipple continued his analysis of the necessary conditions for increased organizational effectiveness in the military health care delivery system. He also began a two-year study, the objective of which is to construct an algorithm to identify the appropriate mix of physician and nonphysician providers to be used in military hospitals. R. T. Harris is a coinvestigator on this latter project.

TECHNOLOGY TRANSFER MANAGEMENT RESEARCH

J. W. Creighton's research on the technology transfer process continued and deepened. The focus of his analysis is on the human interaction with emphasis on the utilization of the process and concepts of technology transfer by managers. Their understanding and relationship to individuals in the organization can highly influence the transfer of technology from source to user and is considered to be one of the prime responsibilities of a successful manager. Other emphasis is on the acceleration of the rate by which results of research are utilized and the resultant benefits for the national economy.

MANAGEMENT SCIENCE RESEARCH

Work in this area, while frequently done in an applied context, is more basic and transferable to a variety of applications. R. A. Weitzman continued his research into the development of predictive techniques useful in manpower/personnel research. Specifically he investigated the derivation and use of true-score estimation of cell frequencies in pattern analysis, as well as the estimation of race or sex bias in ability on achievement tests. N. F. Schneidewind continued his research in the areas of software engineering and management. Results have been obtained which demonstrate a significant relationship between software structure/complexity and error detection and correction. An additional area of Professor Schneidewind's research was the development of design methodologies for computer networks. A. W. McMasters worked with the Naval Electronic Systems Command in identifying causes for budget shortfalls, for provisioning and repairing of newly developed electronic equipment. In addition, he investigated possible internal criteria that could be used for determining the timely transfer of inventory control of such equipment to the ship's part control center of the Naval Supply Systems Command.

RESOURCE ALLOCATION/FINANCIAL MANAGEMENT RESEARCH

The work by Professor Whipple summarized under Health Systems Research above as well as that by C. R. Jones cited in the section on Systems Acquisition Research are also part of this research area. J. M. Fremgen, S. S. Liao, and C. A. Peterson were engaged in the study of an alternative ship building industry structure. K. J. Euske continued his research in the area of the behavioral effects of the budgetary process. In addition, J. M. Fremgen completed a study of Budgeting and accounting practices in certain government activities and reported on the conflict between fixed spending authority and flexible operating requirements.

Title: Research in Officer Manpower and Personnel Planning

Investigators: Edwin A. Alden, Adjunct Professor of Administrative Sciences, James K. Arima, Associate Professor of Operations Research and Behavioral Science, Paul M. Carrick, Associate Professor of Administrative Sciences, Kneale T. Marshall, Professor of Operations Research, Lynn Paringer, Assistant Professor of Economics, Michael G. Sovereign, Professor of Operations Research, Ronald A. Weitzman, Associate Professor of Psychology, Paul R. Milch, Associate Professor of Operations Research, and Patricia A. Jacobs, Associate Professor of Operations Research.

Sponsor: Principal Deputy Assistant Secretary of the Navy (M&RA)

Objective: Development of an interactive model of the officer system for policy analysis and manpower/personnel planning.

Summary: The basic framework of the model will be an integrated, longitudinal flow model of the Navy officer structure that will be aggregated enough to allow for simple and rapid calculations but, at the same time, be rich enough in parameters so that the effects of alternative policies can be demonstrated and examined. In order to provide the necessary richness in the parameters, methods will be developed for determining billet requirements for a projected force structure, behavioral and economic studies will be undertaken to develop parameters sensitive to the choice and demand and supply factors that result from a dynamic interplay of the organization, environment and the individual, a managerial structure for specialty billets will be constructed, and the effects of career paths on the career of individual officers and perceived impact on careers will be modelled. The primary tool for integrating these efforts will be to determine the effects of the variables studied on the transition rates of the flow model.

Title: Effectiveness of Advertising and Promotions

Investigator: James K. Arima, Associate Professor of Operations Research and Behavioral Science

Sponsor: Navy Personnel Research and Development Laboratory

Objective: Develop methods and measures for evaluating the effectiveness of Navy advertising and promotions for recruiting.

Summary: The research began with a thorough examination of the Navy's organization, policies, objectives, programs, and operations in advertising to support recruiting goals. A selective review of the literature on the evaluation of advertising effectiveness and the making of advertising budget decisions was made. The sponsor requested a special evaluation of the Navy Campus for Achievement as a recruit incentive. This was done by a nonreactive approach using available data--requests for promotional literature and coupon returns from magazine advertisements. It was found to have a strong influence in recruiting operations, and a report documented the findings. The available data were insufficient for an empirical evaluation of the Navy's advertising programs, so the limited data were supplemented by self-report data from the twice-yearly DoD Youth Tracking Surveys. A report was prepared for these data that provided insight into the dynamics of the recruiting advertising environment, problems in its evaluation, and the need for appropriate data. The Navy Recruiting Command, through its advertising agency, finally was able to provide detailed data on its national media advertising for calendar years 1976 and 1977. These data have been analyzed to show the relationship between advertising rates and enlistment rates, which turned out to be highly significant only when the advertising rates were transformed using the fourth route of raw advertising before indexing for a rate variable.

Publications: J. K. Arima, "Educational and Training Opportunities as Incentives for Military Service", Technical Report, NPS 54-78-3, February 1978.

Thesis Directed: T. C. Williams, Jr., "Effectiveness of Navy Advertising", Master's Thesis, September 1978

Title: Utilization and Technology Transfer of RDT&E Investment for the Naval Facilities Engineering Command

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsor: Naval Facilities Engineering Command

Objective: Continuing effort for several years has been directed to the enhancement of the effectiveness of NAVFAC R&D investments. Various approaches have been studied concerning methodology for the movement of technology into use or further R&D at a higher than normal usage rate. It is believed that earlier usage of research results would provide for new methods with economic benefits.

Summary: As a result of the studies, a Technology Transfer Model has been developed based on the theory that technology transfer takes place when there is a source, a transfer mechanism of some sort, and utilization of the knowledge by a user or receiver. As yet, quantifying this particular model has not been done but it serves as a very conceptual framework around which to approach the problem. An Information Transfer Model was further developed with varied elements of the model categorized by Formal Factors and Informal Factors. In general, the Formal Factors are the procedures for dissemination of storage, indexing, and retrieval of knowledge. These would include the method of documentation, the distribution system, formal organization of the user, and selection process for projects (User's Contribution). The Informal Factors include interpersonal communications and contracts, personal beliefs and feelings about a knowledge source, perceptions about one's organization, supervisors and peers. Informal elements are the capacity of the receiver, informal linkers in the receiving organization, credibility as viewed by the receiver, perceived reward to the receiver, and willingness to be helped. The R&D organization at NAVFACENGCOM can only make technology available. It cannot induce the desire of a field engineer to make use

of the technology. Efforts are continuing in the development of a significant body of hard data that can serve as a concrete basis to improve the technology transfer environment throughout NAVFACENGCOM for other government and industrial organizations.

Publication:

J. A. Jolly, J. W. Creighton and T. A. Buckles, "Exploratory Development Research Effectiveness, Technical Report NPS 77 Jo091, 1977.

Title: Study of a Tethered Balloon Transport System

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsor: Naval Facilities Engineering Command

Objective: It is the objective of this study to document the impact of containerization on amphibious warfare, review the state of current lighter-than-air technology, trace the development of the commercial Balloon Transport System, summarize the military development effort at discharging containers using a balloon transport system, and to make specific recommendations for the implementation and further development of a Navy Balloon Transport Facility.

Summary: The concept of the Balloon Transport System has been demonstrated to be technologically feasible. All military studies, experiments, and tests involving the use of a tethered balloon system have, without exception, been concluded on a positive note. Evidence exists that the tethered balloon is comparable in vulnerability to all other alternative container-handling systems now in existence or proposed. Cost analysis comparisons of the BTS against other alternative methods reveal that the system is extremely cost effective. It is recommended that further study be conducted to refine existing engineering design data; develop and test a prototype full-scale system taking advantage of the present advances possible with existing technology; and further test and evaluate the prototype system in actual operations to develop standard operating procedures for the operation of the Balloon Transport System.

Publications: None

Thesis Directed: W. F. Graeter II, "Tethered Balloon Transport System: A Proposal", Master's Thesis, June 1978.

Title: Effectiveness, Selection and Evaluation of Navy Exploratory Development Programs

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsors: Naval Weapons Center and Naval Facilities Engineering Command

Objective: Determine the effectiveness of technology base programs with major emphasis on the changing structure of the Exploratory Development Program with the Department of Defense.

Summary: The Exploratory Development Program is being radically revamped. Central to these modifications is the use of dynamic "technical strategies", designed to focus exploratory development more directly and visibly on the operational needs. Worth-assessment processes to date have not been able to be adequately applied to the R&D structure in general, nor the EDP in particular. Primarily, the traditional programs concern the system requirement rather than goal orientation. The future of R&D planning models is not particularly promising in light of observed methodological problems and managerial resistance to their use. The models have not been able to capture all of the relevant and subtle aspects of the R&D and the EDP planning process. One method felt to have high potential in the exploratory development area is that called Evaluation Research. Originally developed for application to social action programs, it is best utilized in situations where sound platforms of goals and objectives can be established. Thus, there appears to be a potentially viable technique which might be applied to programs in the EDP which yield outputs in a somewhat unquantifiable manner. It is strongly recommended that further study be undertaken to more fully explore and demonstrate the potential of this research technique.

Thesis Directed: D. L. Potts, "An Investigation of the Effectiveness, Selection and Evaluation of Navy Exploratory Development Programs", Master's Thesis, December 1977.

Title: The Development of a Fully Automated Procedure to Produce a Technology Transfer Directory of People to Facilitate the Linker Function in the Technology Transfer Process

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsor: Director, Office of Intergovernmental Applications of Science and Technology, National Science Foundation

Objective: Facilitate the communication process in the transfer of technology by developing a fully automated system to produce a directory listing of people who comprise this category. Develop a model by which the process of gathering, storing, extracting, and displaying various types of information is made possible.

Summary: The system developed to accumulate information, maintain a data base and produce a directory has an application broader than the facilitation of the linker function in the technology transfer process. The system was so designed that it could, with minor modifications, be utilized as the basis for any information gathering and display system. The computer programs, which are the foundation of the system, greatly minimize functions associated with gathering, inputting, and maintaining a data base and significantly increase the validity and utilization of this data base through the report generation sub-systems. The automated system developed could be an efficient aid to not only other organizations but also to students in their efforts to accumulate, store, and eventually display their data of thesis research.

Publication: J. W. Creighton and the California State University at Sacramento, 1977 Technology Transfer Directory of People, 1977.

Thesis Directed: R. W. Modrowski and M. M. Henderson, "The Development of a Fully Automated Procedure to Produce a Technology Transfer Directory of People to Facilitate the Linker Function in the Technology Transfer Process", Master's Thesis, June 1978.

Title: Systems Acquisition in Navy Research and Development Laboratories

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsors: Naval Weapons Center and Naval Facilities Engineering Command

Objective: Define the R&D Laboratories' mission and goals, summarize the various studies on the laboratory system, and recommend management techniques for organizational change.

Summary: Acquisition policies of the R&D Laboratories have a definite impact on the type of business conducted and management methods utilized. Political and organizational factors weigh heavily in the changing make-up of the Navy Laboratory System. Each organization should have corporate strategic and tactical plans, an attitude or approach to change with the appropriate organizational structure, and a thorough understanding of the local corporate resources and budget cycle as well as other DoD Laboratories and industry. The laboratory goals should be closely aligned to the mission assignments and clearly defined to all employees. Laboratory R&D Resource Management on a national level is a distinct possibility considering the large expenditures involved. Further studies are recommended and supported for a continuation in the area of resource management during organizational change.

Publications: None

Theses Directed: R. D. Beran and P. R. Decker, "Acquisition Management of Peculiar Ground Support Equipment", Master's Thesis, December 1977.

G. C. Lannou, Jr., "A Study of the Selection of an Information Flow and Analysis System for Naval Underwater Systems Center", Master's Thesis, March 1978.

R. G. Moe, "The Changing Role of Navy Research and Development Laboratories in Systems Acquisition", Master's Thesis, December 1977.

M. S. O'Hearn and C. L. Addison, "An Analysis of NATO Standardization and International Weapons Acquisition Programs", Master's Thesis, March 1978.

E. A. Reed, 3rd P.E., "Less Than Major Systems Acquisition Status and Strategy, with Examples", Master's Thesis, September 1978.

C. G. Van Haaren, "The AGOR-21 Class Oceanographic Research Ships: An Acquisition Analysis", Master's Thesis, March 1978.

Title: Development of a Management and Executive Development Program

Investigators: J. W. Creighton, Professor of Administrative Sciences and
A. C. Crosby, Assistant Professor of Administrative Sciences

Sponsor: Office of Civilian Personnel (Code 03)
Department of the Navy

Objective: Development of a 12-week Management and Executive Development Program for presentation at the Naval Postgraduate School to middle level (GS 13-15 or equivalent military rank) managers.

Summary: Details of Program content in each of several management disciplines were developed and coordinated for presentation in a time period of 12 weeks. Specific topics included: Management Principles and Functions, Organizational Behavior and Theory, Production Management, Human Resource Management, Financial Management and the Governmental Budgeting Cycle, Quantitative Techniques, Organizational Environment, Labor and Personnel Relations, Management Information Systems, and Integration and Application. Presentation materials, including texts, were selected. Promotional brochures and descriptive data and application procedures and forms were developed and distributed to potential Navy users. Based on limited applications received, program has been held in abeyance as a result of a joint decision by OCP and NPS. OP 014 (R. Harrison) is presently pursuing actions aimed at enhancing the demand for this Navy-unique program.

Title: Detail to NPRDC's OP-01 Liaison Office

Investigator: R. S. Elster, Associate Professor of Administrative Sciences

Sponsor: Navy Personnel Research and Development Center

Objective: Perform duties of Senior Scientific Advisor to the Deputy Chief of Operations (Manpower)/Chief of Naval Personnel.

Summary: Performed duties of OP-01r/Pers-Or during the period 1 December 1975 to 30 June 1978. The functions of the incumbent were: (1) Serve as the scientific advisor to DCNO (Manpower)/CNP on matters concerning research and development, and studies and analyses, (2) Participate with OP-01CR and the Manpower and Personnel R&D Committee (MAPRAD) in defining, developing, and executing research programs and studies needed by DCNO (Manpower)/CNP, (3) Provide liaison between the DCNO (Manpower)/CNP organization and relevant research and development activities, (4) Advise DCNO (Manpower)/CNP on status of projects in manpower and personnel, through briefings, discussions and prepared papers, (5) Disseminate scientific and technical information, in the forms of reports and briefings, to the appropriate offices of OP-01/BuPers, (6) Provide technical assistance to the OP-01/BuPers organization in the development of operational requirements (ORs), (7) Serve as co-chairman of the MAPRAD Committee, (8) Serve as the CNP representative on the following committees: a. ONR Manpower Committee; b. Captain Robert Dexter Conrad Award Committee; c. CNET R&D Advisory Working Group; d. Manning Reduction Technology Advisory Group, (9) Serve as a member of the Committee for Enlisted Classification, Selection and Testing (CECSET), (10) Act as CNP studies coordinator and maintain liaison with OP-96 and the Center for Naval Analyses, (11) Serve as a focal point for the development and coordination of personnel surveys required by OP-01/BuPers and disseminate the results of those surveys to appropriate parts of the organizations.

Title: Human Resource Management Research and Support

Investigator: Carson K. Eoyang, Associate Professor of Management

Sponsor: Assistant Deputy Chief of Naval Operations (ADCNO) (Human Resources Management (HRM)) (OP-01p) CAPT A. T. Eyler

Objective: To provide analytic and management expertise to ADCNO (HRM) in the formulation of policy and plans. Additionally, to provide education and training to various commands in the HRM Support System.

Summary: In addition to a five month tour of BuPers to help formulate a Five Year Plan for HRM, the following projects were undertaken: a technical evaluation of existing materials associated with the Navy's Leadership and Management Education and Training Program; an organizational analysis of current Human Resource Management support activities at HRMC Pearl Harbor; and management consulting to headquarters staff around organizational structure and internal functions. Also, the Fourth Annual Inter-Service Conference on Human Resource Management was held at NPS under the auspices of OP-15. Conference proceedings were prepared and soon will be published. Among the major speakers at the conference were Admiral Thomas Hayward, Chief of Naval Operations; Ms. Kathleen Carpenter, Deputy Assistant Secretary of Defense for Equal Opportunity; and Mr. Alexander Silva, Deputy Assistant Secretary of the Navy for Equal Opportunity.

Title: Regulation of Naval Shipbuilding

Investigators: James M. Fremgen, Professor of Accounting, Shu S. Liao, Associate Professor of Accounting, and Clair A. Peterson, Associate Professor of Operations Research and Economics

Sponsor: Naval Sea Systems Command, Code 02, CDR Peter DeMayo, SC, USN

Objective: The objective of the study was to identify the principal implications of alternative industry structures, particularly the public utility alternative, for Navy shipbuilding.

Summary: Each investigator prepared a background paper addressing one aspect of the industry structure problem. Professor Fremgen's paper deals with the basis for valuing the assets of a shipbuilder both for purposes of a transfer of ownership of those assets and for purposes of public utility pricing. Five distinct categories of assets are identified, and valuation bases are proposed for them. The allocation of assets to a shipbuilder which is a subsidiary of a larger corporation was also addressed.

Publications: J. M. Fremgen, "Establishing a Basis for Evaluating the Assets of a Shipbuilding Firm," published in the Naval Center for Acquisition Research (NCAR) Working Paper 79-1, January 1979, "Regulations of Naval Shipbuilding."

Title: Aerospace Industry - DoD Relationship

Investigator: Carl R. Jones, Professor of Administrative Sciences

Sponsor: Office of Naval Research, Code 434
Dr. T. C. Varley

Objective: The objective of this research is the furtherance of the Navy's understanding of the nature of the DoD-private contractor relationship with special emphasis on the aerospace industry. The ultimate goal is to construct a formal model of this relationship which would provide a benchmark for objective public policy analysis.

Summary: I spent my intersessional quarter (Summer 1978) on the first stage of the project collecting data to provide a description of the existing situation. I am continuing on with the project the present quarter and am involved in statistical analyses of the data. This preliminary analysis is expected to be completed by the end of this quarter. A technical report incorporating the results of the analyses and a descriptive model of the existing DoD-aerospace industry relationship will be issued during the winter quarter 1979.

Title: A Study of Alternatives for VSTOL Computer Systems

Investigators: Carl R. Jones, Professor of Administrative Sciences, Uno R. Kodres, Associate Professor of Computer Science, Richard W. Hamming, Adjunct Professor of Computer Science and James D. Buttinger, LCDR, Instructor of Administrative Sciences

Sponsor: Naval Weapons Center, China Lake, California

Objective: The purpose of the study was to assess the impact of Large Scale Integration (LSI) of electronic circuits with respect to future airborne digital systems.

Summary: The study assesses the impact of Large Scale Integration on future airborne digital systems, with a focus on VSTOL systems. The study addresses the design, implementation, testing, servicing and the associated life cycle costs of airborne digital computer systems, both the hardware and the programs necessary for successful operation of the system.

The study provides: information for decision making on the future course of action, a design philosophy, a process analysis methodology, and a life cycle cost analysis method.

Publications: U. R. Kodres, J. D. Buttinger, R. W. Hamming, C. R. Jones, "A Study of Alternatives for VSTOL Computer Systems", Technical Report, NPS 52-78-001, April 1978.

Title: Navy Center for Acquisition Research

Investigators: Robert Judson, Adjunct Professor of Administrative Sciences and Michael G. Sovereign, Professor of Operations Research

Sponsor: Naval Weapons Center, China Lake

Objective: Initiation of a central point in the Navy for planning and dissemination of acquisition research.

Summary: The center was established with outside funding in the Fall of 1978. Professor Judson, Executive Director of NCAR commenced work on a project manager's guide as the principal task. In April he resigned from this position and NPS. Professor Sovereign was appointed Acting Executive Director. Planning for the continuation of the Center as a permanent institution is underway. A draft of part of the project manager's guide was circulated within the Navy. The Acting Executive Director participated in the development of the Navy's plan for acquisition research for the next five years.

Publications: S. M. Dean, C. R. Jones and M. G. Sovereign, "The Naval Ship Acquisition Process as a System", Navy Center for Acquisition Research Working Paper 78-1, February 1978.

J. D. Finnerty, "A Dynamic Stochastic Model of Corporate Behavior Over the Business Cycle With a Special Application to the Major U.S. Military Airframe Builders", MCAR Project 78-2, February 1978.

Conference Presentations: R. Judson, "Aerospace Industries Conference Procurement and Finance", presented at the Annual Conference of Aerospace Industries Association Procurement and Finance Division, San Diego, California, September 1977.

R. Judson, "National Contract Management Association Educational Symposium", presented at the Annual Southeast Region Educational Symposium for the National Contract Management Association, St. Petersburg, Florida, February 1978.

M. G. Sovereign, "Navy Experiences with Design to Cost" presented at the American Institute of Industrial Engineers Seminar on Design to Cost, San Francisco, CA, 21 April 1978.

- Title:** An Analysis of the Conceptual Foundation of the Cost Accounting Standards Board's Cost Allocation Model
- Investigator:** Shu S. Liao, Associate Professor of Administrative Sciences
- Sponsor:** Foundation Research Program (6.1)
- Objective:** To examine the compatibility of CASB's cost allocation methods with the generally accepted accounting principles and evaluate the validity of assumptions.
- Summary:** This study examines whether there is a coherent, consistent theory behind the cost allocation methods promulgated by the Cost Accounting Standards Board and whether the conceptual foundation is compatible with the generally accepted accounting principles. All CASB Standards and the relevant Armed Service Procurement Regulations are reviewed and analyzed. Results indicate that the bases for cost allocation selected by the CASB tend to be more restrictive than generally accepted accounting principles. The CASB emphasizes causal and beneficial relationship. However, the term "causal and beneficial relationship" has been used rather loosely. No statistical evidence is available to support that beneficial relationship can be objectively established. A hierarchy of CASB's allocation bases was identified.
- Conference Presentation:** R. J. Huefner and S. S. Liao, "The CASB and the Allocation Issue", paper presented at the American Accounting Association Western Regional Meeting, 1978.
- Publication:** S. S. Liao, "The Matching Concept and Cost Allocation," Accounting and Business Research (Fall 1979).

Title: Rate of Return Determination for a Regulated Naval Shipbuilding Industry

Investigator: Shu S. Liao, Associate Professor of Administrative Sciences

Sponsor: Naval Material Command

Objective: To determine how the rate of return should be developed and what rate of return should be allowed if the naval shipbuilder were to be regulated as a utility firm.

Summary: This report presents an overview of the rate of return regulation in general and discusses the major events that entail regulatory actions by the traditional public utility commissions in general and by the proposed "Naval Shipbuilding Commission" in particular. The study examines the potential upper and lower limits of the rate of return that the regulated shipbuilder should be allowed. A revised rate of return concept for the regulated shipyard was proposed and requirements for implementation were discussed.

Publication: Shu S. Liao, "Regulating Naval Shipbuilders", working paper 79-1, Navy Center for Acquisition Research submitted to Naval Material Command

Title: Stock Migration from NAVELEX to SPCC

Investigator: Alan W. McMasters, Associate Professor of Operations Research and Administrative Sciences

Sponsor: Naval Electronic Systems Command, Code 504A

Objective: This is a continuing research effort addressing the question of when inventory management of an item should be transferred from NAVELEX to SPCC.

Summary: In an attempt to identify parameters which would be useful in determining when an item could have its management logically transferred from NAVELEX to SPCC, the following steps were taken: 1. Determine the current way NAVELEX manages its repairables. 2. Determine the current way SPCC manages its repairables. 3. Compare inventory management techniques of NAVELEX and SPCC. 4. Determine the extent of current stock transfer activities between NAVELEX and SPCC. 5. Determine the role and influence of NAVMAT on stock migration. 6. Determine the current budget procedures covering the life cycle of an electronic component. 7. Examine demand data to see if it suggests points in time for stock transfer. 8. Discuss problems of unstable electronic equipment with the engineers. 9. Determine ways to alleviate budget shortfalls for NAVELEX managed items.

As a consequence of taking these steps, recommendations were made to NAVELEX for changing their inventory management and budgeting procedures and their procedures for provisioning new components.

Publication: A. W. McMasters and R. L. Hanson, "Budgeting for Repairable Secondary Items at the Naval Electronics Systems Command", Technical Report, NPS 54-78-007, September 1978

Theses Directed: A. J. Petersen and M. W. Casey, "Inventory Migration from the Naval Electronic Systems Command to the Ships Parts Control Center", Master's Thesis, March 1978.

R. N. Seebeck, "The Effects of the Stock Coordination Program upon Inventory Management at the Naval Electronics Systems Command", Master's Thesis, June 1978.

Title: Software Engineering

Investigator: N. F. Schneidewind, Professor of Administrative Sciences

Sponsor: Naval Air Development Center

Objective: Investigate the relationship between program structure complexity and error and test characteristics.

Summary: A high correlation has been found between program complexity and error characteristics, number of errors and labor time required to direct and correct errors. This has been demonstrated with empirical results, supported by simulation and analytical models. Program complexity has also been found useful for partitioning a program into sub-structures for testing purposes.

Conference Presentations:

N. F. Schneidewind, "An Experiment in Software Error, Data Collection and Analysis", Sixth Texas Conference on Computing Systems, University of Texas, Austin, Texas, November 1977.

N. F. Schneidewind, "Software Error Data Collection and Analysis", 1978 Computer Simulation Conference, Newport Beach, CA, July 1978.

N. F. Schneidewind, "Comparison of Software Error Simulation and Real Program Results", Joint National TIMS/ORSA Meeting, New York City, NY, May 1978.

Publications:

N. F. Schneidewind and H. M. Hoffman, "An Experiment in Software Error Data Collection and Analysis", Transactions on Software Engineering, July 1979 (to appear).

N. F. Schneidewind, "The Application of Program Graphs and Complexity Analysis to Software Development and Testing", Transaction on Reliability, August 1979, (to appear).

N. F. Schneidewind and H. M. Hoffman,
"Software Error Data Collection and
 Analysis", Proceedings of the 1978 Sum-
 mer Computer Simulation Conference,
 AFIPS Press, 1978, pp 748-53.

Thesis Directed: Carl W. Monk, Jr., "Experiments in Demon-
 strating the Correctness of Software",
Master's Thesis, September 1978.

Title: Relationships Between Psychological Test Scores, Academic Achievement and Career Success

Investigator: John Senger, Professor of Administrative Sciences

Sponsor: Foundation Research Program (6.1)

Objectives: To determine if there are statistically significant relationships between psychological tests variables, academic achievement at the Naval Postgraduate School and officer promotions.

Summary: 415 Naval officers enrolled in the Management Curriculum at the Naval Postgraduate School between 1964 and 1972 took a variety of psychological tests including: the Allport-Vernon-Lindzey Study of Values (AVL), the Edwards Personal Preference Schedule (EPPS), the California "F" Test for Authoritarianism (Cal F), the A-S Reaction Study (AS), the Minnesota Multiphasic Personality Inventory (MMPI), the California Psychological Inventory (CPI), the Graduate Record Examination (GRE-v and GRE-q). The Grade Point Average and the Naval Postgraduate School (GPANPS) was also included in the promotion analysis.

A pair-wise regression analysis of this data revealed 11 of the 70 variables included in the above tests were significantly ($p > .05$) related to officer promotion. The multiple regression coefficient for the highest 10 partial correlations is a disappointing .36.

A comparison of test scores for officers early promoted (deep selected) and those who were passed-over for promotion show 6 of the 70 variables to be significant at the .05 level or better based on "Students t" test.

Variables which show statistical significance include the Cal F (negative), EPPS Abasement (negative), MMPI Lie Score (positive), MMPI Hypochondriasis (negative), MMPI Psychothemia (negative), MMPI First Factor (negative), MMPI Ego Strength (positive), MMPI Caudality (negative), MMPI Dependency (negative). Four of the eighteen CPI variables were significant at the .10 level in the passover/deep-select comparison. These include Dominance,

Capacity for Status, Tolerance and Flexibility.

A discriminate analysis of the data for a sample of 206 officers for whom GRE, AVL, EPPS, MMPI and GPANPS scores were available identified 37% passovers and 39% deep selects correctly. 92% of the officers receiving normal promotions were identified. 75% of all the promotion actions were correctly identified. No deep-selects were identified as passovers or vice-versa. Discriminate analysis of data for 256 officers who took the GRE, AVL, Cal F, EPPS and GPA identified only 12% officers who were passed over and 11% deep promoted. 97% officers receiving normal promotions were identified. 71% of the total sample were correctly identified.

A search of the literature reveals that very modest results of the kind described above are typical of studies relating personality characteristics to managerial success.

With academic achievement as the dependent variable the results were dramatically different. Pearson correlation coefficients for 23 of 69 personality and intelligence variables are significant at the .05 level. 14 of these are significant at the .01 level. Two of these, GRE math ($r = .66$) and GRE verbal ($r = .45$) are significant at the .001 level.

Personality variables which correlate at the .01 level or better include Cal F Authoritarian (negative), EPPS Achievement (positive), EPPS Intracception (negative), MMPI Lie Score (positive), MMPI Hypomania (negative), CPI Capacity for Status (positive), CPI Responsibility (positive), CPI Tolerance (positive), CPI Achievement via Conformance (positive), CPI Psychological Mindedness (positive).

The multiple regression coefficient for the 10 variables with the highest partial correlations is a very significant .75.

The total sample of 415 officers were divided on the basis of their NPS grade point average into a top one-third, middle one-third

and lower one-third. A discriminate analysis with these three GPA classes as criteria was conducted for a sample of 206 officers who had taken the GRE, AVL, EPPS and MMPI. 88% who fell in the top third were identified, as were 71% in the middle third and 79% in the bottom third. Overall, 80% were correctly identified. Another sample of 114 officers were similarly analyzed. 83% who fell in the upper third were identified, as were 71% of the middle third and 82% of the lower third. Overall, 78% of this sample were identified.

Title: Aggregation of Enlisted Pay Grades and Service Ratings by Tasks Performed

Investigator: R. A. Weitzman, Associate Professor of Administrative Sciences

Sponsor: Foundation Research Program (6.1)

Objective: To illustrate spatial representation of job positions in which distances indicate extent of differences in tasks performed.

Summary: Application of hierarchical cluster analysis and multi-dimensional scaling to Naval Occupational Task Analysis Program data on Navy Electronic Technicians resulted in a two-dimensional map of job positions defined by pay grade and service rating.

Publication: R. A. Weitzman, "Aggregation of Enlisted Pay Grades and Service Ratings by Tasks Performed: Implications for Officer Subspecialty Aggregation", Technical Report, NPS 54-78-008, December 1978

Title: Manpower, Personnel, Training, and Material Resource Interfaces

Investigator: Ronald A. Weitzman, Associate Professor of Psychology

Sponsor: Bureau of Naval Personnel, NMPC-5, (Captain R. B. King)

Objective: The original objective had been to determine the feasibility of developing language interfaces among manpower, personnel, training and material activities. Because of time constraints due to the length of time required to let the contracts, the objectives have been revised to: (1) Assess the use of NOTAP data to develop Class-A school curricula, and (2) formulate a recommendation regarding the possible merger of NOTAP and NEPDIS.

Summary: Contractors have completed a preliminary report on objective (1). The assessment is that the communication between NODAC and CNET needs improvement. The output of NODAC appears to be too difficult to apprehend, not sufficiently current, and too much restricted to what-is rather than what-should-be of optimal use to CNET in its efforts to develop curricula. A formal version of this report for distribution is in preparation. An additional--and final--report is due on objective (2).

Title: Officer Subspecialty Aggregation for Personnel Substitution and Manpower Planning

Investigator: R. A. Weitzman, Associate Professor of Psychology

Sponsor: Bureau of Naval Personnel (R. K. Lehto, Pers Ax)

Objective: To develop officer data for subspecialty aggregation by hierarchical clustering and multi-dimensional scaling and to illustrate the use of the results in personnel substitution and manpower planning.

Summary: I have arranged to obtain from the Naval Military Personnel Center and the Defense Manpower Data Center historical assignment information reflecting billet proximities for use in hierarchical-cluster and multi-dimensional scaling analyses and have demonstrated how to use the resulting billet aggregations in an adaptation to subspecialty supply and demand of a manpower-planning model developed by Marshall and Grinold.

Publication: R. A. Weitzman, "Aggregation of Enlisted Pay Grades and Service Ratings by Tasks Performed: Implications for Officer Subspecialty Aggregation", Technical Report, NPS 54-78-008, December 1978

Title: Reduction of Shrinkage in Pattern Analysis

Investigator: R. A. Weitzman, Associate Professor of Psychology

Sponsor: Navy Personnel Research and Development Center (E. W. Robertson, Code 301DWR)

Objective: To improve the reliability of cell-frequency estimation in pattern analysis.

Summary: Use of a dual standard for variable selection in a stepwise procedure tended to optimize variable independence within criterion groups as well as predictive validity and thus to produce reliable cell-frequency estimates and reduction of shrinkage in cross-validation.

Conference Presentation: R. A. Weitzman, "Reduction of Shrinkage in Pattern Analysis", presented at the Annual Meeting of the Psychometric Society, Canada, August 1978.

Title: A Sequential Test of Strong Inequalities:
The Prediction of Presidents

Investigator: R. A. Weitzman, Associate Professor of
Psychology

Sponsor: Un-sponsored

Objective: To develop and illustrate a sequential test
of the hypotheses $H_1: \pi_1 < \pi_2$ versus
 $H_2: \pi_1 > \pi_2$

Summary: I have developed the test and applied it in
Monte Carlo trials to the prediction of the
winners in 39 U. S. Presidential elections
with a Type I error probability of .10 and
an average sample number of somewhat over
2,000.

**Conference
Presentation:** R. A. Weitzman, "A Sequential Test of Strong
Inequalities: The Prediction of Presidents",
presented at the Annual Meeting of the
American Statistical Association, San Diego,
California, August 1978

Title: Test Bias: Better Cutting Scores or Better Tests?

Investigator: R. A. Weitzman, Associate Professor of Psychology

Sponsor: Un-sponsored

Objectives: To provide a critical review of the use of multiple cutting scores for the reduction of discrimination in personnel selection. To develop a measure of test bias for guidance in the development and choice of tests having minimal bias.

Summary: In a review and development of work done on test bias, I have indicated that the use of multiple cutting scores is unacceptable as inescapably subject to the charge of reverse discrimination and have devised a measure of test bias in the form of a partial correlation between demographic-group membership and the component of the predictor uncorrelated with the criterion.

Conference Presentation: R. A. Weitzman, "Test Bias: One of Those Partial Correlations Is the Answer", presented at the Annual Convention of the American Psychological Association, Canada, August 1978.

Title: Navy Health Care Systems: Professional/Paraprofessional Personnel Mix Study

Investigator: David Whipple, Associate Professor of Administrative Sciences

Sponsor: Chief of Naval Operations, Office of Systems Analysis

Objective: Develop a methodology for use at the facility (that is, hospital) level in determining the appropriate mix of physician and non-physician providers (NPP) to staff specified institutions.

Summary: The present utilization and cost problems of NPP's in the civilian and military health care sectors are being identified and analyzed. The tasks underlying the present peacetime and contingency staffing requirement of the Navy's health care system will be identified and analyzed and a draft methodology developed. Structured field contact will be undertaken to indicate areas in need of modification. The draft methodology will then be refined and expanded to include a complete implementation strategy, tailored to the Navy's particular needs. The project is scheduled for completion in June 1980. To date, the literature has been searched, contact made, and contracts formalized, with the necessary outside, expert consultants. Preliminary analysis on the basis of the extensive literature search and bibliography compiled.

Title: Naval Officer Career and Quality of Life Study

Investigators: David Whipple, Associate Professor of Administrative Sciences and C. B. Derr, Associate Professor of Management, University of Utah

Sponsor: Office of Naval Research

Objective: To derive policy implications for retention and productivity management of the Officer corps of career choice determinants and the quality of life.

Summary: This is the third year of a three-year study. To date, the research has been designed, data collected, and analysis begun. A final report will be prepared when analysis is complete. The approach used is that of the structured interview which elicit those elements which contribute most significantly to career choice decisions by members of the officer corps.

Title: Estimation of Average Cost Per Beneficiary

Investigator: David Whipple, Associate Professor of Administrative Sciences

Sponsor: Chief of Naval Operations, Office of Systems Analysis

Objective: To estimate the average yearly cost to deliver health care to a member of the Navy's eligible population by facility and/or region.

Summary: The military health services system (MHSS) has traditionally based planning and budgeting on its historical workload data. Such a basis has been criticized as: being unable to identify unmet needs; tending to promote continuance of past practice; being easy to manipulate; and, lacking of prescriptive qualities. In contrast, a system based on cost per beneficiary: focuses on meeting the population's needs; can promote efficiency by ranking facilities on the basis of adjusted relative cost per beneficiary; is less subject to perverse manipulation; and can be prescriptive. This study estimates the cost per beneficiary of the MHSS at the facility level. Cost and population estimates were gathered for each continental United States in-patient facility for FY 76. Both total and capitated costs were derived, where the latter were those dependent on the population. The current methodology for estimating population estimates, and costs per beneficiary were aggregated to, regional, service, and tri-service totals.

Publications: Working paper and journal article in preparation.

Thesis Directed: W. C. Brown and M. J. Roman, "Estimation of Average Cost Per Beneficiary in the Military Health Service System", Master's Thesis, March 1978.

DEPARTMENT OF OPERATIONS RESEARCH

Operations Research is a multi-disciplinary field, a fact which is reflected by the variety of areas covered by the sponsored research of the faculty. The topics can be grouped into broad areas of basic research in the techniques of operations research and its applications to military problems. The techniques are mathematical programming and stochastic modelling. The applications areas are combat models, manpower and personnel, resource allocation, and command, control and communication.

MATHEMATICAL PROGRAMMING

Mathematical programming represents the major optimization tool of operations research and the Naval Postgraduate School contributes to the profession through its basic research in the area.

Joint research by Professor Gordon Bradley and Professor Gerald Brown sponsored by the Office of Naval Research has led to the development of extremely fast mathematical programming codes which exploit the special structure of certain optimization problems. Professor Brown has completed work on the DOD Material Distribution Study application. The optimization system has been compared side-by-side with all major competitors and shown to be at least ten times more efficient for large linear models, and much more so for mixed integer models.

STOCHASTIC MODELLING/STATISTICS

The other major approach in Operations Research is probabilistic model-building and statistical analysis. Many faculty contribute to this area.

Professor Donald Gaver, under National Science Foundation, ONR and Defense Communications Agency funding, has continued development of several models using a diffusion approximation technique for communication systems, computer systems, and for systems involving maintenance and repair. Professor James Esary has continued his studies in reliability including clarifying techniques for reliability specifications for the Naval Weapons Center. Professor Harold Larson and Professor Donald Barr have continued analysis of spectrometric data from oil analysis under sponsorship of the DOD.

Professor Peter Lewis derived properties for additional new stochastic point processes. This work was supported by ONR and resulted in four publications and twelve presentations this year. He also continues work in simulation analysis, particularly development of a revision to the LLRANDOM generator.

COMBAT MODELS

The application of operations research to the development and employment of weapons reflects both the origin of the profession and the special role of the Naval Postgraduate School in the field.

Professor Sam Parry has developed a computer simulation model for tank-anti-tank warfare for the Training and Doctrine Command. This model is now being used for studies supporting current decisions. Professor James Taylor has continued his fundamental studies of warfare via Lanchester-type differential equations including four papers published on work supported by ONR and Army Research office. On this topic a monograph is now nearly completed.

Professor Neagle Forrest has directed the Strategic Systems Project Office research program at the Naval Postgraduate School for several years. In addition, he has produced additional programmable calculator models for magnetic anomaly detection. In a similar area Professor Rex Shudde has been developing routines for hand-held computers for use on board P-3 aircraft for the ASW Pacific patrol squadrons.

Professor Alan Washburn and Professor Bryce Tysver have done work for the Naval Torpedo Station in range studies. Professor Washburn also continued his studies of search and evasion.

MANPOWER AND PERSONNEL

The major cost of the U.S. military is for personnel. Planning and analysis of the personnel system is, therefore, of considerable interest. Professor Kneale Marshall and Professor Paul Milch are developing an interactive model of the Naval officer system for policy analysis and manpower/personnel planning. This is a cooperative research project between the Operations Research and Administrative Sciences departments.

RESOURCE ALLOCATION

Many of the tools of operations research are applicable to the question of how to allocate resources in the military.

Professor Michael Sovereign has participated with Professor Jones of the Administrative Sciences department in the ONR supported study of the government-contractor relationship. Professor Sovereign also serves as a reviewer for a major Navy study of ship maintenance.

COMMAND, CONTROL AND COMMUNICATIONS

Command, control and communications (C³) problems are a uniquely difficult problem for military organizations. Research in this area supports the new C³ curriculum at the Naval Postgraduate School. Professors Donald Barr, Gary Poock and Russell Richards have begun design of experiments for the ARPA-funded Advanced Architectural Test Bed (ACCAT) project.

Title: Tactical Development and Evaluation Program

Investigators: Alvin F. Andrus, Associate Professor of Operations Research and Statistics and Rex Shudde, Associate Professor of Operations Research

Sponsor: Office of Naval Research, Code 230

Objective: Provide planning assistance and review of CNO/ONR Tactical Development and Evaluation Program. Provide HP-67 program for Fleet Tactical Library.

Summary: Professor Andrus participated in planning and reviewing the FY 79 Tactical Development and Evaluation Program. Proposals were reviewed and planning accomplished at COMTHIRDFLEET, COMSUBPAC, COMSURFPAC and COMNAVAIRPAC. On-site contractor review and evaluation was performed in Honolulu, Hawaii and Paoli, Pennsylvania. Professor Shudde worked with COMPATWINGSPAC in developing HP-67 programs for the Fleet Tactical Library.

Title: Statistical Analysis for the TPQ-27 Program

Investigators: Donald R. Barr, Professor of Operations Research and Statistics and F. Russell Richards, Associate Professor of Operations Research

Sponsor: Naval Electronics Systems Command, Mr. William Trisler, Code 54031

Objective: To perform analyses of data in support of the TPQ-27 PSVT sponsored by NAVELEX. This is part of a continuing program.

Summary: Data obtained in a rack position test conducted at White Sands, New Mexico, was analyzed and results were applied to the PSVT problem. Test data obtained to date have been analyzed and recommendations made to the sponsor.

Publications: D. Barr and F. Richards, "Mk 82 Bomb Ejection Sensitivity Test Report", Technical Report, NPS 55-79-02, February 1979.

D. Barr, "Possible Approaches to Determining Lateral and Range Effects of Bomb Stations, Based on Observed Impact Points", Technical Report, NPS 55-78-10, March 1978.

Title: Statistical Procedures for the Joint Analysis Program

Investigators: Donald R. Barr, Professor of Operations Research, Harold J. Larson, Professor of Operations Research and Toke Jayachandran, Associate Professor of Mathematics

Sponsor: Naval Air Rework Facility, Pensacola, Florida

Objective: The joint oil analysis program is a tri-service standardized program to monitor the wear condition (of aircraft engines, etc.) through the use of spectrometric oil analysis. The analysis measures the amount of wear metals in lubricating fluids and provides any indication of unusual wear. The accuracy of such an analysis is dependent on (1) the daily spectrometer calibration routine, (2) the oil standard used for calibration and (3) the quality of the electrodes used. The objective of the project is to develop statistical techniques to ensure that the quality of the electrodes and standard samples meet minimum requirements and the calibration routines are followed accurately.

Summary: Acceptance testing procedure for the standard samples and the electrodes were developed. A three part procedure to examine the performance of each of the spectrometric laboratories as well as to compare these labs with each other were developed. A technical report was issued and the sponsors have extended the project for computer implementation of some of the recommended procedures.

Publications: D. R. Barr, T. Jayachandran, H. J. Larson, "Some Statistical Procedures for the Joint Oil Analysis Program", Technical Report NPS 55-78-08, May 1978.

Title: ACCAT Experiments in Command and Control

Investigators: Donald R. Barr, Professor of Operations Research
Gary K. Poock, Professor of Operations Research
F. Russell Richards, Associate Professor of Operations Research

Sponsor: Naval Ocean Sciences Center, Code 1001

Objective: To design and evaluate experiments in Command and Control for operational demonstrations at the Advanced Command and Control Architectural Testbed (ACCAT) at NOSC, San Diego. This is part of a continuing program.

Summary: Experimentation support was provided to ACCAT for a number of technologies, including displays, threat assessors, query systems and decision aides. A manual was developed which will provide general guidelines to engineering personnel on design and conduct of experiments at ACCAT. (This is currently being prepared as a technical report.)

Publications: D. R. Barr, G. K. Poock, F. R. Richards and H. G. Miller, "Experimentation, Research and Operational Concepts for the Naval Postgraduate School Remote Site Module," Naval Ocean Sciences Center Report, April 1978.

Conference Presentation: D. R. Barr and F. R. Richards, "Characteristics of MOE's in the C³ Setting," Military Operations Research Symposium, Monterey, CA, December 1977.

Title: Statistical Analysis for the Joint Oil Analysis Program

Investigators: Donald R. Barr, Professor of Operations Research, Harold J. Larson, Professor of Operations Research and Toke Jayachandran, Associate Professor of Mathematics

Sponsor: Naval Air Rework Facility, Pensacola, Florida

Objective: To develop statistical designs and analysis procedures for use in several problem areas, including certification monitoring of analysis laboratories, acceptance testing procedures for oil reference standards and acceptance testing of carbon electrodes. This is part of a continuing program.

Summary: Work was completed on the problems of acceptance testing for oil reference standards, carbon electrode testing, and laboratory certification procedures.

Publications: D. R. Barr, T. Jayachandran and H. J. Larson, "Some Statistical Procedures for the Joint Oil Analysis Program", Technical Report NPS 55-78-008, May 1978.

Title: Exploitation of Special Structure in Large Scale Optimization

Investigators: Gordon H. Bradley, Professor of Computer Science and Gerald G. Brown, Associate Professor of Operations Research and Computer Science

Sponsor: Office of Naval Research

Objective: Continued development of theory and algorithms for solution of large scale optimization models.

Summary: The research program has continued on several fronts. Large scale models exhibiting network structure have been intensively studied and applications have been solved with almost one million variables. Large-scale linear and mixed integer optimization models are being studied with newly developed automated pre-optimization analysis routines, and solved with a prototype test-bed optimization system. Results indicate for a wide range of benchmarks that the pre-processing of large models is invaluable both from managerial and mathematical viewpoints. The optimization system has been compared side-by-side with all major competitors and shown to be at least ten times more efficient for large linear models, and much more so for mixed integer models. Using decomposition, problems have been solved with several million variables.

Title: Availability in the Presence of a Finite Spares Backlog

Investigator: James D. Esary, Professor of Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: Develop computational capability for point availability derived from a basic failure-repair process when the spares backlog is finite. Use results to test a conjecture about how availability conforms to that derived from the usual, infinite spares case.

Summary: The failure-repair processes considered are alternating renewal processes with a finite number of cycles. Failure rates and repair rates are assumed constant. Computational effort has been focused on the (practical) cases in which repair rate is larger than failure rate. Closed form solutions for the point availability arising from such processes have been obtained in two boundary cases, infinite repair rate and repair rate equal to failure rate. An integral solution for point availability has been obtained for the intermediate cases. This solution permits experimentation with various computational approximations. Tests of the conformity conjecture done so far seem to support its validity.

Thesis Directed: K. J. Park, "Experimental Availability Tables for Finite Spares Backlogs", Master's Thesis in preparation for March 1979.

Title: Reliability Aspects of a Fleet Air Defense Study

Investigator: James D. Esary, Professor of Operations Research and Statistics

Sponsor: Naval Weapons Center, China Lake, CA

Objective: To provide consulting services on the reliability aspects of competing alternatives in a (classified) fleet air defense improvement study.

Title: Tactical Implication of Magnetic Airborne Detector (MAD) Systems

Investigator: R. Neagle Forrest, Associate Professor of Operations Research

Sponsor: Naval Intelligence Support Center

Objective: The objective of this work was to develop models for evaluating the implications of Magnetic Airborne Detector Systems (MAD).

Summary: A magnetic anomaly detection model has been developed and compared to an existing model. The application of the model to the analysis to appropriate search plans has been indicated. In addition, the search plans have been compared to search plans involving sonobuoy detection systems. The results indicate that, under certain conditions, the effectiveness of a MAD search could be equal to (or greater than) the effectiveness of a sonobuoy search.

Publications: R. N. Forrest, "Magnetic Anomaly Detection Models with a Program for a TI-59 Calculator," Technical Report NPS55-78-021, September 1978.

Title: FBM Effectiveness Studies

Investigator: R. Neagle Forrest, Associate Professor
of Operations Research

Sponsor: Strategic Systems Project Office

Objective: The objective of this work was to
evaluate FBM effectiveness.

Summary: An evaluation of a signal processing
technique was performed.

Publications: R. N. Forrest, "An Evaluation of a
Signal Processing Technique,"
Technical Report NPS55-78-12 (Project
Report), February 1978.

Title: Simulation Methodology

Investigators: Donald P. Gaver, Professor of Operations Research and Statistics, Peter A. W. Lewis, Professor of Operations Research and Statistics

Sponsor: Chief of Naval Research

Objective: Develop mathematical, probabilistic, statistical techniques for describing phenomena in operations research.

Summary: A simple modeling technique has been developed that is useful for representing a wide range of data, such as that arising in reliability and availability, mortality studies, and service system evaluation.

Publications: D. P. Gaver and M. Acar, "Analytical Hazard Representation for Use in Reliability, Mortality, and Simulation Studies", Technical Report NPS 55-78-017, August 1978. To appear in Communications in Statistics.

Thesis Directed: M. Acar, "Analytical Hazard Representations for Use in Reliability, Mortality, and Simulation Studies", Master's Thesis, September 1978.

Title: Stochastic Systems Analysis and Modeling

Investigators: Donald P. Gaver, Professor of Operations Research and Statistics and Peter A. W. Lewis, Professor of Operations Research and Statistics

Sponsor: National Science Foundation

Objective: Develop mathematical techniques for describing various systems.

Summary: Probability models were constructed for extreme-value and record situations (with P. A. Jacobs), for infinite-server systems having time-dependent arrivals (with J. P. Lehoczky), for the reliability of standby nuclear safety systems (with B. Chu), and for statistical estimation and inspection of other standby (sometimes inactive) systems.

Publications:

D. P. Gaver and P. A. Jacobs, "Non-Homogeneously Paced Random Records and Associated Extremal Processes", Journal of Applied Probability, 15, September 1978.

D. P. Gaver, "Modeling and Estimating the Availability of Complex Systems: The Jackknife, Common-Cause, and Inspection Models", in Proceedings of 23rd Conference on Design of Experiments in Army Research Development and Testing, November 1978.

D. P. Gaver and B. B. Chu, "Availability Analysis for Some Standby Systems", in Proceedings of American Nuclear Society, 8-10 May 1978.

D. P. Gaver and P. A. W. Lewis, "First Order Autoregressive Gamma Sequences", Technical Report NPS 55-78-016, August 1978.

D. P. Gaver and J. P. Lehoczky, "Non-Stationary Infinite Server Models and Their Relatives", Technical Report NPS 55-78-026, 1978.

Conference

Presentations:

D. P. Gaver, "Modeling and Estimating the Availability of Complex Systems: The Jackknife, Common-Cause and Inspection Models", presented at the 23rd Conference on the Design of Experiments in Army Research Development and Testing, Monterey, California, November 1978.

D. P. Gaver and B. B. Chu, "Availability Analysis for Some Standby Systems", presented at the Probabilistic Analysis of Nuclear Reactor Safety Topical Meeting, Los Angeles, California, 8-10 May 1978.

Title: Computer System Modeling

Investigator: Donald P. Gaver, Professor of Operations Research and Statistics

Sponsor: Defense Communications Agency

Objective: Develop mathematical models to describe utilization of various system components (CPU, disk drives, etc.), thereby allowing efficient system performance evaluation.

Summary: Various models are being constructed, and will be programmed. Monitor data is being examined and related to the models.

Title: Probability Modeling, Numerical Methodology and Data Analysis for Communications Networks

Investigator: Donald P. Gaver, Professor of Operations Research and Statistics

Sponsor: Office of Naval Research

Objective: Develop mathematical models for various situations in which data and voice messages cooperatively share channels. Predict delays to both message components.

Summary: A model has been constructed that allows assessment of delays under different demand conditions. Computational methods are also under investigation.

Publications: A report is under preparation.

Conference Presentations: D. P. Gaver and J. P. Lehoczky, "A Queueing Problem Involving Voice and Data Transmission Over Partially Shared Channels," ORSA/TIMS Meeting, Los Angeles, CA, November 1978.

Title: NTDS Computer Facilities Scheduling System

Investigators: James K. Hartman, Associate Professor of Operations Research and Administrative Sciences and Gilbert T. Howard, Associate Professor of Operations Research

Sponsor: Fleet Combat Direction Systems Support Activity

Objective: The purpose of this project is to provide system specifications for an interactive NTDS Computer Facilities Scheduling System for FCDSSA/FCDSTCP, San Diego.

Summary: NTDS mockups, digital computers, and various items of computer peripheral equipment are combined into many different configurations for maintenance, training, program development and program test by FCDSSA/FCDSTCP. The variety of different users and configurations creates a complex problem in job and equipment scheduling. This research project has proposed an interactive computer system for accomplishing the scheduling task. Decision logic for the scheduling program has been detailed and tested.

Publications: J. K. Hartman and G. T. Howard, "NTDS Computer Facilities Scheduling System-- Final Report", Technical Report NPS 55-77-45, December 1977.

Title: Models for Determining Munitions Stockpile Requirements

Investigator: James K. Hartman, Associate Professor of Operations Research and Administrative Sciences

Sponsor: Naval Weapons Center

Objective: As an input to acquisition decisions for air to ground weapons, our objective is to estimate munitions requirements for various scenarios as a function of weapon characteristics and their relation to the characteristics of other weapons in the inventory.

Summary: Several models currently in use by the Navy and the Air Force for determining air to ground munitions requirements have been analyzed and compared. The models are found to differ radically in approach and level of detail. Some suggestions are advanced for making these models sensitive to weapons characteristics such as special purpose versus general purpose and to nonlinear aspects of system cost.

Publications: J.K. Hartman, "A Survey of Some Models for Determining Munitions Stockpile Requirements for Air to Ground Weapons", Technical Report NPS 55-78-2, January 1978.

Title: A Target Selection Model

Investigator: Gilbert T. Howard, Associate Professor
of Operations Research

Sponsor: Strategic Systems Projects Office

Objective: To develop a model for selecting from
a set of possible targets a subset
with maximum value.

Summary: A sequential target selection model has
been developed to deal with the selection
problem where a known sequence of target
opportunities is presented. The oppor-
tunities are sequence dependent so that
later choices are limited by decisions
made previously in the selection process.
The model has been expanded to include
the simultaneous selection of more than
one sequence maximizing the total value
of the targets selected.

Publications: G. T. Howard, "A Target Selection Model,"
Technical Report NPS55-78-30, October
1978.

Thesis: One thesis is in preparation.

Title: LLRANDOMII Random Number Generator Package

Investigator: P. A. W. Lewis, Professor of Operations Research

Sponsor: Foundation Research Program (6.2)

Objective: Further development of the LLRANDOM package to include the most recent methods for generating normal, gamma, exponential and uniformly distributed random variables. Also the inclusion of subroutines to generate Poisson and geometric random variables.

Summary: It was determined that several recently proposed schemes for generating normal and gamma distributed random variables were no better than those already included in LLRANDOM I. Several schemes for generating Poisson and geometric random variables were tried and the two best schemes were put into LLRANDOMII. Several new multipliers for the pseudo-random number generators were tried and two chosen. Thus LLRANDOMII has pseudo-random number generators, shuffled and unshuffled, with two different multipliers. The whole package was reprogrammed in ASSEMBLY language as separate subroutines.

Publications: Luis C. Uribe, "The New LLRANDOMII Package Random Number Generator Package", published by Systems Exploration, Inc., 30 September 1978.

Luis C. Uribe, "The New LLRANDOM Package LLRANDOMII, Users Guide", published by Systems Exploration, Inc., 30 September 1978.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM.(U)

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Title: Aircraft Carrier Landing Patterns

Investigator: Kneale T. Marshall, Professor of Operations Research

Sponsor: None

Objective: To analyze landing pattern strategies under various landing conditions to determine optimum bolter-hole spacings.

Summary: The probability of a successful landing aboard a carrier varies with weather conditions, time of day, experience of pilot, etc. To accommodate planes that bolter (do not make a successful landing), spaces are left in the landing pattern so that these planes can be vectored back into the landing pattern. Analyses were carried out to determine the optimum spacing of these bolter holes for different landing probabilities and different objective functions, including: minimize time to recover a squadron, minimize expected fuel consumed in recovery.

Publications: K. T. Marshall, "An Analysis of Bolter-Hole Spacing in Aircraft Carrier Landings," Technical Report NPS55-78-013, May 1978.

Title: A Quantitative Analysis of Political Unrest in Eastern Europe

Investigator: Paul R. Milch, Associate Professor of Operations Research and Statistics

Sponsor: DOD-Washington Headquarters Services, Directorate of Budget and Finance, Room 3B269, Pentagon, Washington, DC 20301. Point of Contact: Mr. Andrew Marshall, Director of Net Assessment, Office of the Secretary of Defense, The Pentagon.

Objective: To study political unrest in Eastern Europe in order to discover any possible association between that and economic hardship.

Summary: Political unrest data was obtained for the six Warsaw Pact allies of the Soviet Union from the Inter-University Consortium for Political and Social Research. This data was studied and organized using time series techniques in the APL language. Economic data was obtained for one country (Hungary), but it appeared that because this data was annual it could not be compared in a meaningful way to the political unrest data which was daily. Whereas aggregation of the latter into weekly, monthly or even quarterly periods is clearly possible and desirable, in annual aggregation the relevant fluctuations in the political unrest variables are lost. A summary of these variables in various graphical and tabular forms, however, reveal interesting comparisons both within countries across various time periods and among the six countries studied. The research is continuing.

Publications: A Naval Postgraduate School Technical Report is under preparation.

Title: Design Parameters in Color CRT Displays

Investigator: Douglas E. Neil, Assistant Professor of Operations Research

Sponsor: Naval Ocean Systems Center

Objective: Examine effectiveness and applicability of color in CRT display design.

Summary: The effort consisted of an examination of existing literature on the question of color coding in CRT design. A comprehensive search of existing and on-going research relative to operator characteristics, task demands, coding requirements, performance specifics, display characteristics, ambient environment, etc., was conducted. Results indicated that the question of color use was not well documented. At the present, little can be said relative to specific applications of color in CRT display design. The only conclusion possible based on existing research is that each application must be considered individually.

Publications: D. E. Neil, "Design Parameters in Color CRT Displays", NPS Technical Report in preparation.

Title: Conference on Occupational Safety and Health Analyses

Investigator: Douglas E. Neil, Assistant Professor of Operations Research

Sponsor: Office of Naval Research
CDR R. E. James

Objective: Project designed to examine the questions of identification, evaluation, analysis and prediction through convening of a conference on the general subject of occupational safety and health.

Summary: As a result of conflict with elements within NAVSEA actual convening of the conference could not proceed as originally scheduled. However, meetings have been held with various agencies involved with occupational safety and health within the Navy and several contractors currently examining the problem. The conference has been delayed but will be held at a later date.

- Title:** Case Study Development Concerning Ship Acquisition Process in the U.S. Navy As It Relates to Both the Executive and Legislative Branches of the Government
- Investigators:** J. F. Owens, CDR; J. D. Buttinger, LCDR; and S. M. Dean, Associate Professor of Administrative Sciences
- Sponsor:** Duke University/Rand Graduate Institute, Public Policy Curriculum Materials Development Program
- Objective:** To develop curriculum case study materials in the area of U.S. Navy ship acquisitions. Purpose is to improve both the quality and quantity of public sector case materials for teaching purposes at the Naval Postgraduate School and to make greater utilization of government documentation than is now available in typical business school cases.
- Summary:** Two case studies have been written as thesis-directed projects. Current evaluation within the Administrative Sciences Department is being conducted. LCDR J. D. Buttinger has been transferred and Professor S. M. Dean is no longer working with the project. Professor L. Darbyshire is assisting in the evaluation of the case study projects.
- Theses Directed:**
- (1) Frederick Bigelow Easton, "Case Study: FFG-7 Class Ship," Master's Thesis, June 1978.
 - (2) John Demetrius Vellis, II, "Case Study: Escalation Clauses in Shipbuilding Contracts," Master's Thesis, June 1978.

Title: Analysis of XML Battlefield Effectiveness

Investigator: Samuel H. Parry, Associate Professor of Operations Research

Sponsor: U.S. Army Training and Doctrine Command, Fort Monroe, VA

Objective: To initiate development of a study plan using the STAR model to analyze the ammunition requirements for the XML tank.

Summary: Development of the Simulation of Tactical Alternative Responses (STAR) model represents a continuing research effort. The initial status of the model was an operational simulation of artillery versus an attacking enemy ground force using a parametric terrain representation. As a result of this research a two-sided ground combat model at the company versus battalion has been completed and provides the basis for continuing the model development for larger combat units.

Publications: S. H. Parry, "The Generation and Use of Parameterized Terrain in Land Combat Simulation", in Proceedings of the 1977 Winter Simulation Conference, December 1977.

S. H. Parry and M. Benkel, "Scatterable Mines: Evaluation, Deployment and Detection", in Proceedings of the Sixteenth Army Operations Research Symposium, January 1978.

Conference Presentations: S. H. Parry, "The Generation and Use of Parameterized Terrain in Land Combat Simulation", presented at the 1977 Winter Simulation Conference, Gaithersburg, Maryland, December 1977.

S. H. Parry and M. Benkel, "Scatterable Mines: Evaluation, Deployment and Detection", presented at the Sixteenth Army Operations Research Symposium, Fort Lee, Virginia, October 1977.

1977.

Title: Development of the Simulation of Tactical Alternative Responses (STAR) Combat Model

Investigators: Samuel H. Parry, Associate Professor of Operations Research and James K. Hartman, Associate Professor of Operations Research

Sponsor: U.S. Army Training and Doctrine Command, Fort Monroe, VA

Objective: To continue development of the STAR model to evaluate land combat effectiveness at each hierarchical level of combat.

Summary: A significant requirement exists in the Army for a land combat model capable of representing combat at any hierarchical level required. Currently, many models exist, but there is very little capability to use these models in tandem because of their independent development. This research program is being executed in four phases. The near-term Battalion Model (Phase I) will be production ready in December 1978 and will represent all pertinent ground weapon systems in the combined arms environment. The long-term Battalion Model (Phase II) will be available in mid-1979 to describe both training and hardware contributions to total system error budgets. The Brigade Model (Phase III) will represent both ground and air combat at the element level and will be in production status in May 1979. The Division-Corps Model (Phase IV) represents a continuing effort to represent the C³ functions as they relate to resource allocation and force disposition. This continuing effort is currently supported by 24 NPS student theses in Operations Research and Computer Science.

Publications: S. H. Parry, E. P. Kelleher, W. S. Wallace and E. G. Hagewood, "STAR: The Combat Model for Analysis of XM-1 Stowed Load Configurations", in Proceedings of the Seventeenth Army Operations Research Symposium, January 1979.

S. H. Parry and J. R. Kelley, "Ammunition Transport Capability in Support of a Combat Unit", in Proceedings of the Seventeenth Army Operations Research Symposium, Fort Lee, VA, January 1979.

S. H. Parry and E. P. Kelleher, "Simulation of the Tactical Employment of Field Artillery", in Proceedings of the Seventeenth Army Operations Research Symposium, Fort Lee, VA, January 1979.

S. H. Parry, "STAR: Simulation of Tactical Alternative Responses", in Proceedings of the 1978 Winter Simulation Conference, Miami Beach, FL, February 1979.

S. H. Parry, J. K. Hartman, E. P. Kelleher, W. S. Wallace and E. G. Hagewood, "STAR Model: Design, Development and Application", NPS Technical Report to be published.

Conference
Presentations:

S. H. Parry, E. P. Kelleher, W. S. Wallace and E. G. Hagewood, "STAR: The Combat Model for Analysis of XM-1 Stowed Load Configurations", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry and J. R. Kelley, "Ammunition Transport Capability in Support of a Combat Unit", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry and E. P. Kelleher, "Simulation of the Tactical Employment of Field Artillery", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry, "STAR: Simulation of Tactical Alternative Responses", 1978 Winter Simulation Conference, Miami Beach, FL, December 1978.

Theses Directed: L. P. Gibson, "A Method to Determine Divisional Engineer Battalions' Training Measures of Effectiveness", Master's Thesis, September 1978.

J. R. Kelley, "Simulation and Analysis of Ammunition Transport Capability in Support of a Combat Unit", Master's Thesis, March 1978.

S. H. Barry and E. P. Kelleher, "Simulation of the Tactical Employment of Field Artillery", in Proceedings of the Seventeenth Army Operations Research Symposium, Fort Lee, VA, January 1978.

S. H. Barry, "STAR: Simulation of Tactical Alternative Responses", in Proceedings of the 1978 Winter Simulation Conference, Miami Beach, FL, February 1978.

S. H. Barry, J. M. Hartman, E. P. Kelleher, W. S. Wallace and D. G. Hagerwood, "STAR Model: Design, Development and Application", WPS Technical Report to be published.

S. H. Barry, E. P. Kelleher, W. S. Wallace and D. G. Hagerwood, "STAR: The Combat Model for Analysis of XM-1 Stowed Load Configurations", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Barry and J. R. Kelley, "Ammunition Transport Capability in Support of a Combat Unit", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Barry and E. P. Kelleher, "Simulation of the Tactical Employment of Field Artillery", Seventeenth Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Barry, "STAR: Simulation of Tactical Alternative Responses", 1978 Winter Simulation Conference, Miami Beach, FL, December 1978.

Thesis Directed: J. P. Gibson, "A Method to Determine Divisional Engineer Battalion's Training Measures of Effectiveness", Master's Thesis, September 1978.

Title: Model Development and Analysis in Support of Army Combat Vehicle Technology Program

Investigator: Samuel H. Parry, Associate Professor of Operations Research

Sponsor: U.S. Army Armor and Engineer Board, Fort Knox, KY

Objective: To initiate development of a mid-resolution combat model (STAR) to analyze light weight, agile combat vehicles.

Summary: During previous contracts with the sponsor, the investigator developed models and analyzed field data to assess the contribution of mobility and agility to battle-field survivability. In order to evaluate the worth of highly mobile vehicles in the land combat environment, a force-on-force model of high resolution is required. In response to this requirement, development of the Simulation of Tactical Alternative Responses (STAR) model was initiated. The current status of the model is a high resolution company versus battalion model capable of representing highly agile vehicles so that field data is directly usable in the model. This research effort is part of a continuing program to develop a hierarchical set of models to support a wide range of Army analysis requirements.

Publications: S. H. Parry, "The Effect of Target Vehicle Agility on Tank Gunners," Proceedings of the Sixteenth Army Operations Research Symposium, January 1978.

Conference Presentation: S. H. Parry, "The Effect of Target Vehicle Agility on Tank Gunners," Sixteenth Army Operations Research Symposium, Fort Lee, VA, October 1977.

Title: A Preliminary Evaluation of Three Alternative Navy Shipbuilding Industry Structures

Investigator: Clair A. Peterson, Associate Professor of Operations Research and Economics

Sponsor: Naval Sea Systems Command

Objective: The purpose of the research was to evaluate new approaches to the ship acquisition process. Specifically these approaches involved regulation of the shipbuilding industry and long-term contracts for production.

Summary: The preliminary evaluation strongly suggests that regulation of the shipbuilding industry would reduce economic efficiency, and perhaps reduce Navy/Industry conflict over contested claims for reimbursement.

Publications: C. A. Peterson, "Regulation of Naval Shipbuilding," Navy Center for Acquisition Research, Naval Postgraduate School, Monterey, CA, October 1978.

Title: Definition of Initial Operating Capabilities and Experiments in the Advanced Command and Control Architectural Testbed (ACCAT) and in the NPS Remote Site Module (NPS-RSM)

Investigators: Gary K. Poock, Professor of Operations Research, Donald R. Barr, Professor of Operations Research and F. Russell Richards, Associate Professor of Operations Research

Sponsor: Naval Ocean Systems Center, Code 832

Objective: To set up initial operating capabilities for experiments at ACCAT and to design plans for initial network experiments between NOSC, FNWC and the command and control center (NPS-RSM) being installed at the Naval Postgraduate School.

Summary: Initial operating capabilities and network experiments have been developed to demonstrate command and control scenarios and to demonstrate real-time access to up-to-date weather from FNWC which will impact on the scenario in progress.

Publications: D. R. Barr, G. K. Poock, F. R. Richards and H. G. Miller, "Experimentation, Research and Operational Concepts for the Naval Postgraduate School Remote Site Module", Naval Ocean Systems Center Technical Report, April 1978.

D. R. Barr, G. K. Poock and F. R. Richards, "Experimentation Manual, Part I: Experimentation Methodology" Technical Report NPS 55-78-032, November 1978.

Conference Presentation: G. K. Poock, "Teaching Military Officers Command and Control Technologies Using the ARPANET", presented at the Advanced Command and Control Architectural Testbed (ACCAT) Principal Investigators Conference, San Diego, California, October 1978.

Thesis Directed: T. E. Warren, "A User's Guide for the RITA Production Rule System", Master's Thesis, June 1978.

Title: Asymptotic Efficiency of Point Estimators

Investigator: Robert R. Read, Professor of Operations Research, Probability and Statistics

Sponsor: Un-sponsored

Objective: To develop guidelines for choosing estimating equations when the full maximum likelihood system is too difficult to solve.

Summary: This is a continuing project and progress was reported last year. In addition, this year's work includes success in using the empirical Laplace transform as a replacement equation when dealing with the gamma and negative binomial distributions.

Thesis Directed: R. Caglayan, "Efficient Estimation of Negative Binomial Parameters Using Empirical Laplace Transform," Master's Thesis, September 1978.

Title: Development of a Software Package for Exploratory Data Analysis

Investigator: F. Russell Richards, Associate Professor of Operations Research

Sponsor: None

Objective: Develop an APL software package for use by students and faculty at NPS for exploratory data analysis.

Summary: A software package consisting of sample data, documentation and APL functions was developed and installed as an APL Public Library on the NPS Time Sharing System for use by students and faculty at NPS. The library includes functions for plotting and displaying data, regression, analysis of variance, summary statistics, goodness of fit tests, and analysis of residuals. The library is used extensively by students in the statistics and data analysis courses.

Publications: F. R. Richards, "A User's Guide to the OA 3660 APL Workspace," Technical Report NPS55-78-028, October 1977.

Title: Computer Assisted Target Positional Analysis for P3 Aircraft

Investigator: Rex H. Shudde, Associate Professor of Operations Research

Sponsor: Office of Naval Research

Objective: The objective is to optimize new and existing algorithms for in-flight use of fleet tactical ASW aircraft. Major areas include acoustic and nonacoustic search, target classification and sensor data processings.

Summary: An environmental range prediction model for the AN/SSQ-50/50A and AN/SSQ-62 sonobuoys has been developed and programmed for the Hewlett-Packard HP-67/97 programmable calculator; this program has been submitted to COMPATWINGSPAC for inclusion in the Fleet Mission Program Library.

Title: Aerospace Industry

Investigators: Michael G. Sovereign, Professor of Operations Research
 Carl R. Jones, Professor of Administrative Sciences
 Toke Jayachandran, Associate Professor of Mathematics

Sponsor: Office of Naval Research, Code 430

Objective: Extend previous government-contractor behavior modeling to a data base to be developed on the aerospace industry.

Summary: Rather recently the DRI system has become available. With this data, three areas are under investigation. The first of these concerns the empirical testimony of John Kurth's "Follow-on" and "Bail-out Imperatives." This hypothesis is one aspect of two broader areas--the risk of the aerospace industry as a whole relative to other industries in the economy and the relative risk of individual firms within the industry. Very preliminary results hint that the relative riskiness in both cases may not be as large as some sources in the aerospace industry have suggested.

Publications: S. M. Dean, C. R. Jones and M. G. Sovereign, "The Naval Ship Process as a System," NCAR Paper 78-1.
 M. G. Sovereign, "Comments on the Financial Performance of Companies in the Aerospace Industry," Report to sponsor.

Theses Directed: J. A. T. C. Rodrigues, "The FFG-7 Frigate An Application of the Design-to-Cost Concept," Master's Thesis, September 1978.
 J. V. Diekemper, "The Financial Input of Shipbuilding Claims Upon Litton Industries," Master's Thesis, September 1978. Second reader.
 J. G. Kuchinski, Jr., "Quantitative Analysis of Defense Expenditure Patterns in Warsaw Treaty Organization Countries 1960-1974," Master's Thesis, September 1978. Second Reader.

Title: Maintenance System Development

Investigators: Michael G. Sovereign, Professor of Operations Research
James D. Esary, Professor of Operations Research and Statistics

Sponsor: Naval Sea Systems Command, PMS-306

Objective: Provide an outside monitoring of the technical reports of the Maintenance System Development Program (MSDP).

Summary: This is a continuation of the review of the work done for PMS-306 by a number of contractors participating in the MSDP, a five-year, multi-million dollar effort to improve the maintenance of the Navy's surface ships. The investigator serves on the three technical panels monitoring the work.

Publications: More than ten reviews have been prepared for the project manager. A number of meetings of technical panels and contractors have also been attended.

Title: Lanchester-Type Models of Warfare
(Monograph)

Investigator: James G. Taylor, Associate Professor
of Operations Research

Sponsor: Office of Naval Research, Code 431,
Mr. James G. Smith

Objective: To continue writing a monograph on Lanchester-type (i.e. differential-equation) models of warfare. The monograph will be a state-of-the-art summary as well as an introduction to analytical models of force-on-force combat attrition and will attempt to integrate and synthesize widely scattered results and modelling ideas. Also, to deliver an invited presentation "Attrition Modelling" at the 3rd Annual Systems Science Seminar of the Hochschule der Bundeswehr München in Munich, West Germany.

Summary: Work was continued from the previous year. A detailed outline for the monograph has been developed and revised several times. During this report period, the overall plan of the monograph was revised and several additional chapters written. At present the monograph is to consist of eight chapters: of these three are completely written, two are completely written except for illustrations (i.e. figures), and three chapters are only partially completed. A draft manuscript of between 700 and 800 pages has so far been produced. Additionally, an invited presentation on attrition modelling was delivered at the Hochschule der Bundeswehr in Munich, West Germany. The text of this presentation has been integrated into the draft manuscript of the monograph. Future plans are to finish writing the three incomplete chapters and to try to complete the monograph during the next fiscal year.

Publications: J. G. Taylor, Chapter titled "Attrition Modelling," in Operationsanalytische Spiele für die Verteidigung by R.K. Huber, K. Niemeyer and H.W. Hofmann, Oldenbourg, 1979.

Title: Optimization of Combat Dynamics

Investigator: James G. Taylor, Associate Professor of Operations Research

Sponsor: U.S. Army Research Office, Mathematics Division, Dr. Robert L. Launer

Objective: To extend the state-of-the-art for the quantitative determination and analysis of optimal time-sequential combat strategies in scenarios of tactical interest. Consideration to be given to extensions of evaluation methodologies, problem formulation, combat-modelling methodologies, and/or optimization theory as required by specific time-sequential tactical allocation problems. Also, methodology for the analysis of existing combat models to be developed and/or extended as required for the quantitative analysis of strategy and tactics.

Summary: Progress was made in two broad areas: (1) obtaining insights into the dynamics of combat by studying relatively simple Lanchester-type force-on-force combat models, and (2) investigating optimal time-sequential tactical decisions with such simple models. An invited paper on recent developments in the Lanchester theory of combat was delivered at the 8th IFORS International Conference on Operational Research. However, the major portion of research effort was devoted to developing better analytical means for investigating the nature and implications of Lanchester-type combat models. Substantial progress was made on parametrically analyzing combat modelled by variable-coefficient Lanchester-type equations of modern warfare. A general mathematical theory for force-annihilation-prediction conditions was developed and is based on new mathematical results on the zeros of nonoscillatory (in the strict sense) solutions to second-order linear ordinary differential equations. Such force-annihilation prediction involves a so-called "parity-condition" parameter, and a numerical procedure for determining this important parameter was developed. Tabulations of new mathematical functions

that facilitate parametric analysis of an important class of "aimed-fire" combat problems were developed. Research was also conducted on approximate solutions (and associated error analysis) to several classes of variable-coefficient differential-equation combat models, including generalizations of both Lanchester's "square-law" and also "linear-law" equations. A differential-equation model was used to quantitatively investigate the military principle of "concentration". Future plans include the further investigation of battle-outcome-prediction conditions during the next year.

Publications:

J. G. Taylor, "Approximate Solution (with Error Bounds) to a Nonlinear Nonautonomous Second-Order Differential Equation", Journal of the Franklin Institute, Vol. 306, No. 2, August 1978.

J. G. Taylor and G. G. Brown, "Numerical Determination of the Parity-Condition Parameter for Lanchester-Type Equations of Modern Warfare", Computers & Operations Research, Vol. 5, No. 4, 1978.

J. G. Taylor, "Optimal Commitment of Forces in Some Lanchester-Type Combat Models", Operations Research, early 1979.

J. G. Taylor, "Prediction of Zero Points of Solutions to Lanchester-Type Differential Combat Equations for Modern Warfare", SIAM Journal on Applied Mathematics, Vol. 36, No. 3, June 1979.

J. G. Taylor, "Some Simple Victory-Prediction Conditions for Lanchester-Type Combat Between Two Homogeneous Forces with Supporting Fires", Naval Research Logistics Quarterly, Vol. 26, No. 2, June 1979.

J. G. Taylor, "Recent Developments in the Lanchester Theory of Combat", chapter in Operational Research '78, K. B. Haley (Editor), North-Holland, early 1979.

J. G. Taylor, "Attrition Modelling", chapter in Operationsanalytische Spiele für die Verteidigung, R. K. Huber, K. Niemeyer and H. W. Hofmann, Oldenbourg, early 1979.

J. G. Taylor, G. G. Brown, "A Table of Lanchester-Clifford-Schläfli Functions", Technical Report NPS 55-77-39, October 1977.

J. G. Taylor, G. G. Brown, "A Short Table of Lanchester-Clifford-Schläfli Functions", Technical Report NPS 55-77-42, October 1977.

Conference

Presentations:

J. G. Taylor, "Some Simple Victory-Prediction Conditions for Lanchester-Type Combat Between Two Homogeneous Forces with Supporting Fires", presented at TIMS/ORSA Joint National Meeting, New York, 3 May 1978.

J. G. Taylor, "Recent Developments in the Lanchester Theory of Combat", Eighth IFORS International Conference on Operations Research, Toronto, Canada, 20 June 1978.

Theses Directed:

P. A. Bigelman, "An Analysis of a Lanchester-Type Combat Model Reflecting Attrition Due to Unit Deterioration and Ineffective Combatants", Master's Thesis, March 1978.

D. C. Chadwick, "The Evaluation of Design and Employment Alternatives for the LVA: A Modelling Strategy", Master's Thesis, September 1978.

Title: Instrumental Range Studies - Torpedo Path Estimation

Investigator: J. Bryce Tysver, Associate Professor of Operations Research

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, Washington

Objective: To extend existing track smoothing program at NUWES to include higher order functional polynomials. To improve estimates of torpedo heading direction with respect to the target in the terminal homing phase.

Summary: The general track smoothing program (MASM3DRJ) in use at NUWES uses linear, parabolic, and logarithmic functions to fit 3-D data files on torpedo paths by the method of least squares. Polynomial functions of the first (linear), second (parabolic), third, and fourth orders were fitted to data for a variety of path segments of a torpedo run at NUWES using the method of least squares. Results suggest expansion of the program to include higher order polynomials and fitting shorter path segments will provide substantial reduction in residual errors. The method of sequential differences was tried on the data and can be incorporated in the smoothing program as a means of identifying outlier data points and of selecting the appropriate polynomial order for fitting the data.

Publications: J. B. Tysver, "Smoothing 3-D Data for Torpedo Paths," Naval Postgraduate School Technical Report, NPS55-78-36, 1978.

Title: Search Evasion Game in a Fixed Region

Investigator: Alan R. Washburn, Associate Professor
of Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: To solve or approximate the solution to a game where the searcher lays a series of traps for the Evader. If the Evader escapes one trap, he has enough time to go anywhere in the region before the next one is laid. The payoff is the mean time to detection.

Summary: The game has been solved. The value of the game depends on only two characteristics of the region: its volume and characteristic distance (d). d is the mean distance between two points that are selected independently and uniformly at random in this region. The mean time to detection is proportional to d^4 .

Publications: A. R. Washburn, "Search Evasion Game in a Fixed Region", submitted to Operations Research.

Title: Range Studies Project

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, Washington

Objective: To determine the value of Kalman Filtering for range tracking in Dabob Bay.

Summary: A simulation of tracking by Kalman Filters in Dabob Bay was constructed. The filtering appears to be of substantial value only when tracking arrays are imperfectly located.

Publications: A. R. Washburn, "Simulation of Kalman Filter Used for Short Baseline Underwater Tracking", Technical Report NPS 55-78-015, July 1978.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

The research program of the Department of National Security Affairs has continued along several main lines: (1) Politico military analysis with a focus on particular geographic areas, (2) Perceptions and perception management, (3) Analysis of Soviet military exercises, (4) Net assessment, and (5) Operational test and evaluation.

POLITICO MILITARY ANALYSIS

Work focused on Western Europe has continued to emphasize understanding the character and evolution of European Communist parties and their influence on the viability of the NATO Alliance. With regard to the Soviet Union, the primary emphasis has been on the role of the Soviet Union in the third world, with particular emphasis on the relationship between the Soviet Union and Cuba as it relates to Soviet use of Cuban proxies in the Horn of Africa and Angola.

In the Middle East, research has focused on the analysis of Arab political elites through the use of biographical data.

PERCEPTIONS AND PERCEPTION MANAGEMENT

The Department has, for a number of years, engaged in original research on methods for measuring third-country perceptions of the U.S. - Soviet military balance and identifying the principal causes of change in those perceptions. Arising out of this work, we have developed an interest in questions of perceptions management and deception in international relations, negotiations, and war. The department is currently managing a substantial interdisciplinary research effort in this area which we expect to continue over the next few years.

ANALYSIS OF SOVIET MILITARY EXERCISES

The department continues to examine trends in Soviet military exercises and to develop techniques for relating exercises to each other. Soviet exercises play an important role, together with major procurement decisions and doctrinal writings in interpreting Soviet military strategy and intentions.

NET ASSESSMENT

There are two main efforts in this area: continuing analysis of the Soviet-U.S. strategic balance and an analysis of the military balance in southern Africa.

OPERATIONAL TEST AND EVALUATION

Based on prior research conducted at NPS on the effectiveness of aircraft against tanks in World War II, the department has been engaged in a major program of test and evaluation of the A10 aircraft against tanks and other FEBA targets.

Title: Perceptions of the Superpower Military Balances: Considerations and Evidence

Investigator: Donald C. Daniel, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objectives: (1) Help systematize the research field centering on perceptions of the superpower military balances; and (2) Offer empirically based conclusions as to the comparative rankings of the superpowers in perceived strength, the factors which condition those views, and the policy consequences flowing from them in the minds of the perceivers.

Summary: The study was divided into three parts. The first presented a general "map" of the research field as it raised and organized questions and problems faced by an analyst. It also provided the rationale for arguing that U.S. policy-makers should more consciously consider the perceptions impact of their force development and deployment decisions. Part two illustrated the use of different research methods and sources with the focus being on American, Soviet, British, French, German, Japanese, and Arab views of various superpower balances. Part three highlighted and drew together findings derived from part two.

Publications: D. C. Daniel, International Perceptions of the Superpower Military Balances, Praeger Press, 1978.

D. C. Daniel, "Perceptions of the Superpower Military Balances: Considerations and Evidence", Technical Report NPS 56-78-001, February 1978.

Title: Soviet Naval Operations and Exercise Analysis

Investigator: Donald C. Daniel, Assistant Professor of National Security Affairs and W. C. Reese, Professor of Physics and Chemistry

Sponsor: Naval Intelligence Command/NFOIO(IAD)

Objective: Increase the analytical proficiency of Naval Intelligence Curricular students; and support NFOIO(IAD) in its research effort.

Summary: The substantive focus of this research program is to ascertain trends and patterns in major Soviet naval exercises, ASW aircraft utilization, and ship internal C³.

Publications: Donald C. Daniel, "Trends and Patterns in Major Soviet Naval Exercises", Naval War College Review, (Spring 1978), pp 221-232.

Theses Directed: Classified

Six other theses are in preparation.

Title: Comparative Analyses of Major Soviet Fleet Exercises

Investigators: D. Daniel, Assistant Professor of National Security Affairs and W. Reese, Professor of Physics and Chemistry and National Security Affairs

Sponsor: Naval Intelligence Command, Naval Field Operational Intelligence Office, Independent Analysis Detachment

Objective: To make comparative analyses of major Soviet fleet exercises during the period 1967 to 1976 and to establish indicators of forthcoming naval exercise activity.

Summary: An examination was made of major Soviet Naval exercises occurring between 1967 and 1976 in an attempt to establish indicators of forthcoming naval exercise activity. This examination was conducted in two phases. In the first phase an analysis was made of the timing and emphasis of major Soviet Naval exercises in the past decade to establish historical experience of some of the more firmly entrenched exercise series. In the second phase an intensive examination was made of the indicator events which were reported for a limited set of exercises. It was found that all exercises investigated displayed a number of observable precursors. General patterns of precursor events preceding major exercises of different types were suggested.

Title: Arab Political Elites: A Preliminary Analysis of Selected Elites

Investigators: Ralph H. Magnus, Assistant Professor of National Security Affairs
John W. Amos, II, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To examine the biographical data files maintained at the CIA, supplemented with biographical data obtained from open Arabic and English language sources, in order to develop a study which will inventory and present aggregate biodata, as well as correlate elite characteristics within countries, across countries and over time concerning Egypt, Syria and Saudi Arabia.

Summary: Problems of security clearances made it impossible thus far to examine the raw data files at the CIA. The project has, however, collected data from open sources and from the published classified reports of the CIA, as well as order of battle material from the U.S. Army. Categories for analysis to the completed material have been developed. Further NPS Foundation sponsorship is being sought to complete the data collection phase once the security clearances have been obtained and to obtain computer programming and analysis support in developing the data base structure, encoding the data, summary and analysis programming.

Publications: An article on the sub-elite of the Saudi-Arabian cabinet and the Royal Family will be completed in January, 1979 for submission to The Middle East Journal.

Title: The Military Balance in Southern Africa

Investigator: Barry M. Schutz, Assistant Professor of National Security Affairs

Sponsor: Net Assessment Office, Washington Headquarters Services, Department of Defense

Objective: To provide broad description of military actors in region with their motives and links. To graphically portray the military participation and supply activities of actors in region. To recommend specific future programs for data acquisition and classification of military activity in the region.

Summary: Description on a broad canvas of specific zones of inter/intra state military combat; identification of internal and external military conflict and consensus between the actors (internal and external) in the region. Dynamic levels of military capacity evinced in comparative battle capacity portrayed in contemporary statics and by dynamic trend. Support and supply links between regional combatants and external powers elaborated. Military survival capability of various actors in region--particularly those in the "white redoubt" are examined. The trend perspective is yielding perspectives on the enormous build-up focusing upon the Republic of South Africa internally and the Soviet Union and Cuba externally. Results indicate Zambia's ultimate military significance as a swing state within the subsystem, prolonged military conflict in Rhodesia (burgeoning increasingly into a regional race war), and real social change taking place within the South African Defense Forces with possible impact on the military involvement of other actors throughout the region. The project's subsequent focus should be on the South African military experiment in conjunction with South African military actions in the region. Subsequent data-acquisition and classification ought to be procedurally regularized either through interstate conflict synopses or event data.

Publications:

B. M. Schutz, "The Military Balance in Southern Africa: Zones, Actors, Perceptions", Africa Today, Spring 1979.

B. M. Schutz, "Military Perceptions in Southern Africa", in preparation for Naval War College Review, 1979.

Conference**Presentations:**

B. M. Schutz, "The Military Balance in Southern Africa: Zones, Actors, Perceptions", presented at African Studies Association Meeting, Baltimore, MD, 1-4 November 1978.

Title: Data Analysis and National Security Policy-Making

Investigator: Ronald G. Sherwin, Assistant Professor of National Security Affairs

Sponsor: Cybernetics Technology Office, Defense Advanced Research Projects Agency; and Command and Control Technical Center, Office Joint Chief of Staff, J-5

Objective: Develop and maintain sequential international event data base for crisis management research program; develop systematic, computer-oriented measurement techniques for assessing the impact of arms transfers in LDC's; and develop software for coding, managing and retrieving arms transfer information in Real-time.

Summary: The Research developed a multi-attribute utility technique for assessing the effect of conventional weapons transfers on Third World military capabilities. The project also developed and demonstrated a set of computer software for managing arms transfer information. The project is part of the Crisis Management Research Program sponsored by the Cybernetics Technology office (DARPA) for developing a set of counter-oriented decision aids to be used in international crisis decision-making.

Publications: Edward J. Laurance, "Congress and Arms Control: The Case of Conventional Arms Transfer", submitted to International Studies Association, February 1978.

Edward J. Laurance and Ronald G. Sherwin, "Understanding Arms Transfer Through Data Analysis", Arms Transfers to the Third World, Geoffrey Kemp, et al (eds), Denver, Westview Press, 1978.

Edward J. Laurance and Ronald G. Sherwin, "The Measurement of Weapons Systems Balances: Building Upon the Perception of Experts", Perceptions of the Superpower Military Balance, Donald Daniel (ed.), New York, Praeger, 1978.

Ronald G. Sherwin and Edward J. Laurance, "Arms Transfer and Military Capability: Evaluating Arms Transfer to Developing Countries", International Studies Quarterly, forthcoming.

Ronald G. Sherwin, et al., "Naval Postgraduate School Arms Transfer Handbook", Department of National Security Affairs, U.S. Naval Postgraduate School, Monterey, California, June 1978.

Ronald G. Sherwin, et al., "The Management and Analysis of Arms Transfer Information", Technical Report, NPS-56-79-002, September 1978.

Conference
Presentations:

Ronald G. Sherwin, "Rethinking the Prospects for a General Theory of International Relations", presented to International Studies Association, Washington, D. C., February 1978.

Theses Directed:

Lowell E. Jacoby, "Quantitative Assessment of Third World Sea Denial Capabilities", Master's Thesis, December 1977.

Patrick M. O'Connell, "Measuring Arms Transfer with Multiple Attribute Utility Theory", Master's Thesis, December 1977.

Title: Lethality Tests of Air Force Gun Ammunitions Against Arrival Target Arrays

Investigator: Russel H. Stolfi, Associate Professor of National Security Affairs

Sponsors: Air Force Systems Command, Wright Patterson AFB, Ohio and Air Force Development and Test Command, Eglin AFB, Florida

Objective: Continued realistic testing of the lethality of GAU-8 (30 mm Gatling gun) ammunition against tank targets.

Summary: The research program has continued to contribute to lethality tests of GAU-8 ammunition conducted on range 63, Nellis Air Force Base, Nevada. Tests of the A-10/GAU-8 weapon system have proceeded from firings at individual combat loaded tank targets through tactically arranged arrays of 31 tanks. All firings have taken place at low aircraft dive angles and have shown conclusively that the A-10/GAU-8 can effectively damage modern MBTs under low altitude attack conditions and ranges of engagement from approximately 4000-2000 feet.

Publications: R. Stolfi, J. Clemens, R. McEachin, "A-10/GAU-8 Low Angle Firings Versus Individual Combat Loaded Soviet T-62 Tanks (17 February - 10 March 1978)" Combat Damage Assessment Team Report, Wright Patterson Air Force Base, Ohio, 1 February 1979, 80 pp.

R. Stolfi, J. Clemens, R. McEachin, "A-10/GAU-8 Low Angle Firings Versus Simulated Soviet Tank Company (10 Combat Loaded M-47 Tanks) 10 March 1978", Combat Damage Assessment Team Report, Naval Postgraduate School, Monterey, California, in process of publication.

Title: The Soviet-Cuban Intervention in Angola

Investigator: Jiri Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To continue study of Soviet and Cuban military involvement in general and to assess the external and internal factors which influenced the Soviet-Cuban management of the Angolan crisis of 1975. To use the results in the formation of a probable pattern for the prediction of future Soviet and Cuban military involvement in Africa.

Summary: Two studies, drawing extensively on Soviet, Cuban and African sources, were further developed and revised in preparation for publication.

Publications: Jiri Valenta, "Soviet-Cuban Decision-making and the Intervention in Angola, 1975", published in David Albright (edition), The Great Powers in Africa, Indiana University Press, Spring, 1979.

Jiri Valenta, "Soviet-Cuban Intervention in Angola, 1975", published in Studies in Comparative Communism, published at the University of Southern California, Spring-Summer 1978.

Thesis Directed: Paul Hoffman and Bruce Book, "Soviet Involvement in Africa: A Descriptive and Quantitative Analysis", Master's Thesis, March 1978.

Title: Eurocommunism and Eastern Europe

Investigators: Jiri Valenta, Assistant Professor of National Security Affairs and David Burke, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To assemble papers and edit an anthology which would further develop theories on Eurocommunism previously analyzed by Professor Valenta in "Eurocommunism and Eastern Europe", Problems of Communism, March-April 1978. To convene a two-day conference on Eurocommunism at the Naval Postgraduate School (August 21-22, 1978) for the presentation of invited papers by leading national experts on Eurocommunism and its effects on the countries of Eastern Europe, the USSR and NATO.

Summary: The conference fulfilled the objectives above, bringing together the leading experts in this field who delivered papers on the historical development, practice, and impact of Eurocommunism, and NPS students who are working on theses in this area and who served as discussants. The principal investigators (Valenta and Burke) and Visiting Professor Vernon Aspaturian served as organizers of the conference and editors of the proceedings. Professor Valenta wrote and presented two papers and chaired one panel. Professor Burke chaired one panel and served as discussant on another.

Conference Presentations: Jiri Valenta, "The USSR and Eurocommunism", presented at the Inter-University Research Colloquium of the Institute for Sino-Soviet Studies at George Washington University, April 11, 1978.

Jiri Valenta, "The USSR and Eurocommunism" presented at the conference on Eurocommunism and Eastern Europe, August 21-22, 1978, Department of National Security Affairs of the Naval Postgraduate School.

Jiri Valenta, "Czechoslovakia and Eurocommunism", presented at the conference on Euro-communism and Eastern Europe, August 21-22, 1978, Department of National Security Affairs of the Naval Postgraduate School.

Publications:

J. Valenta, V. A. Aspaturian, D. P. Burke, Eurocommunism Between East and West, Indiana University Press, Fall 1979.

J. Valenta, "The USSR and Eurocommunism", Czechoslovakia and Eurocommunism", and "Eurocommunism and Eastern Europe". J. Valenta's contributions will appear as a chapter in this book.

Theses Directed:

D. Helms, "The Eurocommunist Challenge and the East European and Soviet Response", Master's Thesis, June 1977.

P. Dahlquist, "Yugoslavia in the Post-Tito Era: Implications for Internal and External Crisis", Master's Thesis, March 1979.

D. Weidler, "Eurocommunism and NATO", Master's Thesis, March 1979.

- Title:** Bureaucratic Politics Paradigm and the Soviet Invasion of Czechoslovakia
- Investigator:** Jiri Valenta, Assistant Professor of National Security Affairs
- Sponsor:** Foundation Research Program (6.1)
- Objective:** To further develop and refine analytical paradigms (modified and tailored to the Soviet circumstance) for analysis of Soviet national security policy making.
- Summary:** This study focuses on the Soviet national security decision making process and used the Czechoslovak crisis of 1968 as a case study. The results show that the bureaucratic politics paradigm can substantially illuminate many aspects of decision making which have not previously received sufficient attention, and suggest that focusing on the dynamics of the role played by the bureaucracies can be useful in the analysis of Soviet national security and foreign policy behavior.
- Conference Presentations:** Jiri Valenta, "Bureaucratic Politics and Soviet Foreign Policy", presented at the Annual National Convention of the American Association for the Advancement of Slavic Studies (AAASS), Washington, D. C., October 16, 1977.
- Publications:** Jiri Valenta, "Bureaucratic Politics Paradigm and the Soviet Invasion of Czechoslovakia", Political Science Quarterly, Winter 1979.
- Thesis Directed:** Tom Wynkop, "Ideology as a Determinant of Soviet Foreign Policy: A Second Look", Master's Thesis, June 1979.

Title: The USSR and the Somalian-Ethiopian Conflict

Investigator: Jiri Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To assess the Soviet and Cuban military intervention in the Horn of Africa in 1977-78. (This study is the outgrowth of an earlier research project on the Soviet-Cuban intervention in Angola which has been published in a scholarly journal and as part of an anthology.)

Summary: The research for this paper, which relies extensively on Soviet, East European and African sources, was conducted with Captain Gary McGraw who is my student. The results indicate a new assertive pattern in Soviet and Cuban behavior characterized by military involvement in the Third World in general and in Africa in particular. The Soviet-Cuban intervention in Ethiopia came about as a result of this trend. Other related factors were qualitative and quantitative improvement of Soviet sea- and air-lift capabilities, perfection of Soviet-Cuban military cooperation, Soviet strategic objectives in the Red Sea, accurate assessment of the U.S. response, and pressure of Soviet domestic and bureaucratic politics. There is a remote likelihood that military intervention by the Soviets and Cubans (and lately the East Germans), if not countered, may be repeated in other strategically important areas of Africa: Namibia, South Rhodesia, and elsewhere. This topic calls for further careful examination by experts on the subject in the form of a conference.

Publications: J. Valenta and G. McGraw, "The Soviet-Cuban Military Intervention in the Horn of Africa", (completed technical report not yet published). The paper has also been submitted for consideration to a scholarly magazine.

Theses Directed: D. Stone, "Namibia 1978: Another Angola?",
Master's Thesis, March 1979.

R. Shields, "A Reevaluation of Soviet
Military Strategy in Southern Africa",
Master's Thesis, March 1979.

The research for this paper, which relies extensively on Soviet, East European and African sources, was conducted with Captain Gary McGraw who is my assistant. The results indicate a new assertive pattern in Soviet and Cuban behavior characterized by military involvement in the Third World in general and in Africa in particular. The Soviet-Cuban intervention in Ethiopia came about as a result of this trend. Other related factors were qualitative and quantitative involvement of Soviet and air-land-sea capabilities, perception of Soviet-Cuban military cooperation, Soviet strategic objectives in the Red Sea, economic advancement of the U.S. response, and pressure of Soviet domestic and bureaucratic politics. There is a remote likelihood that military intervention by the Soviets and Cubans (and lately the East Germans), if not countered, may be repeated in other strategically important areas of Africa (Angola, South Rhodesia, and elsewhere). This topic calls for further careful examination by experts on the subject in the form of a conference.

J. Valenta and G. McGraw, "The Soviet-Cuban Military Intervention in the Horn of Africa", (unpublished technical report not yet published). The paper has also been submitted for consideration to a scholarly magazine.

Title: Soviet Intervention in Czechoslovakia, 1968

Investigator: Jiri Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To collect new data through research and interviews with Soviet and East European refugees in the United States and Western Europe for final revision of a book-length manuscript to be published by a leading academic press.

Summary: The research was conducted on several fronts and completed. The principal investigator reviewed additional post-intervention sources and conducted several important interviews in Western Europe with former leading decision-makers from communist countries which greatly enhanced the final version of the manuscript.

Publications: Jiri Valenta, Soviet Intervention in Czechoslovakia, 1968: Anatomy of a Decision, Johns Hopkins University Press, Spring 1979.

Theses Directed: Robert McConnell, "Conventional Military Weapons and Soviet Foreign Policy", Master's Thesis, March 1978.

Dallace Meehan, "Poland: National Autonomy or Soviet Invasion?", Master's Thesis, March 1978.

DEPARTMENT OF PHYSICS AND CHEMISTRY

During the reporting year, members of the Department have been involved as principal investigator in 28 individually identified or funded research projects, representing a total of 780,000 dollars in research funds.

Although spanning a large number of areas, 95% of the Department's research efforts could be summed under the title, "Science of Interfaces". The interface between man-made systems and their functioning in a non-manipulable environment governed by physical laws, principal concerns in many weapon systems developments, has over recent years become more and more the focal point around which the Department's research efforts are grouped.

While still keeping in touch with the forefront of pure basic physics through the continued efforts in (1) Nuclear Physics, the Department's efforts in (2) Underwater Acoustics, (3) Acoustics, (4) Atmospheric Physics, (5) Geomagnetic Phenomena, (6) Laser and Plasma Physics, (7) Atomic Physics, (8) Solid State and Surface Physics and (9) Weapons and Weapons Effects are all in a general sense concerned with the exploration of interface phenomena and are all of high relevance to present and future weapon systems.

NUCLEAR PHYSICS

F. R. Buskirk, J. N. Dyer and R. Pitthan and students have continued their investigation of multipole resonances completing a survey of Quadrupole and Octopole resonances through the periodic table.

UNDERWATER ACOUSTICS

A. Coppens and J. V. Sanders and students have continued their theoretical and experimental investigation of the transmission of acoustic energy from an ocean of decreasing depth into a fast bottom and theory and experiment appear to converge. H. Dahl has pursued his development of Ray Tracing Algorithms for the accurate positioning of sound sources for the underwater acoustic range of the Naval Undersea Warfare Station. H. Medwin with his students investigated ocean parameters affecting sound propagation along several lines. Methods of decreasing signal fading of surface reflected sonar signals, removing the reverberation of the shallow water environment, acoustical shadowing of surface backscatter near grazing incidence and the source levels of marine

mammals were investigated. J. V. Sanders studied the possibility of obtaining source levels of sources of unknown location in the presence of reverberation. O. B. Wilson together with members from the Departments of Electrical Engineering and Operations Research has continued his program of studies of long range problems for the Naval Undersea Warfare Station mostly in the areas of ship and underwater weapons testing.

During most of FY 78, the Department hosted Dr. I. Tolstoy, well known geophysicist, who occupied the Chair for Underwater Acoustics which was funded by ONR and the Director of Naval Technology. Dr. Tolstoy studied the scattering of acoustic waves from randomly rough surfaces which led to the prediction of the existence of a surface mode never discussed before. Toward the end of the year, experiments conducted by H. Medwin and students were highly encouraging in demonstrating the actual existence of these waves.

ACOUSTICS

A. Coppens and O. B. Wilson were studying the generation, propagation and detection of flexural waves in beams for possible shipboard signaling systems and O. B. Wilson and students pursued the development of a 75khz transducer which makes use of flexural waves on a flash mounted plate and which is to be used on acoustic tracking ranges.

A new sort of activity was begun in support of the Naval Rework Facility. Investigation of noise characteristics of pneumatic hand tools were begun by H. Dahl, J. V. Sanders and K. Woehler.

ATMOSPHERIC PHYSICS

Still the largest group effort, the investigation of optical properties in the marine boundary layer with E. C. Crittenden, A. W. Cooper, E. A. Milne, W. Rodeback and R. Armstead and students participating has now moved into the problem of optical extinction with the development of measurements techniques for the extinction due to fog and aerosols over the ocean which are to be correlated with aerosol particle size and meteorological measurements.

G. E. Schacher together with Dr. C. Fairall and members from the Departments of Meteorology and Mechanical Engineering have continued the fog and aerosol studies. These studies involved measurement of heat and momentum surface layer

fluxes to determine mixing rates for Los Angeles air basin pollution models; the dynamics of the West Coast marine inversion and its relation to surface fluxes, the fog dynamics at San Nicolas Island to obtain scaling laws for fog formation and the evaporation duct height over the ocean to obtain vertical profiles for the refractive index.

GEOMAGNETIC PHENOMENA

The investigation of geomagnetic phenomena begun by O. Heinz last year has been continued together with P. Moose and first measurements of magnetic field fluctuations on the ocean floor have been made.

LASER AND PLASMA PHYSICS

F. Schwirzke has continued his investigation of laser produced plasmas with emphasis on the magnetic field generation at the steep shock like front of the expanding plasma cloud. Also continued has been the laser induced surface analysis which is a cooperative effort with DoE supported fusion research at UCLA. Two new efforts were started this year. F. Schwirzke studied laser induced acoustic pulses in water and together with K. Woehler a DNA funded program on x-ray emission from laser induced pinches was begun which supports the DNA x-ray flux simulation efforts.

ATOMIC PHYSICS

Our Spectroscopic Data Center directed by R. Kelly continues its long range program of providing definitive compilations of data. A compilation stored on magnetic tape of all lines for the first 18 elements for all stages of ionization has been completed. Work on the compilation of all lines below 2000 Å for the first 36 elements is in progress and a special compilation of 30000 lines for the first 36 elements in the 2000 - 3000 Å region has been completed in support of NASA's space exploration and solar physics program.

SOLID STATE AND SURFACE PHYSICS

D. E. Harrison has continued his trajectory studies of low energy ion impact mechanism on crystal surfaces this year in cooperation with researchers at Purdue University, which are directed toward a better understanding of mechanisms of surface chemistry.

WEAPONS AND WEAPONS EFFECTS

Under this heading all Department efforts related to either physical weapons effects or analysis of whole weapon systems are collected. W. Reese has continued his support for the Naval Intelligence community. Together with members from the NSA Department, he was involved in a comparative analysis of major Soviet Fleet exercises, an open literature technical forecast study and the development of a threat forecasting methodology.

R. A. Reinhardt, G. Kinney and K. Graham have continued their investigation of internal blast phenomena with thermo chemical calculations directed toward determination of pressures resulting from explosions in confined spaces.

Title: Investigation of Nuclear Giant Resonances by Inelastic Electron Scattering

Investigators: F. R. Buskirk, Professor, J. N. Dyer, Professor and R. Pitthan, Visiting Professor of Physics and Chemistry

Sponsors: Foundation Research Program (6.1) and National Science Foundation

Objective: A survey of the fundamental modes of nuclear oscillation, called giant resonances, has been extended to light elements such as Ni and Si, as well as a closer investigation of Ce.

Summary: Giant resonances are the fundamental modes of oscillation of nuclei. The giant dipole resonance is well known from gamma absorption experiments, while the quadrupole and other modes have been investigated since 1971 by electron, proton and alpha particle scattering. The NPS research, using electrons, has constituted a survey of the nuclear table, including ^{238}U , ^{208}Pb , ^{197}Au , ^{165}Ho , ^{140}Ce , ^{89}Y , ^{58}Ni , ^{60}Ni , and ^{28}Si . The quadrupole and dipole modes are well known, appearing at $60 A^{-1/3}$ and $80 A^{-1/3}$ MeV, where A is the mass number. The survey has emphasized higher energy quadrupole and octopole modes, not seen in proton or alpha scattering.

One particularly interesting result concerns the monopole breathing mode, which is a symmetric expansion of the nucleus. We had early results indicating its presence at $53 A^{-1/3}$ MeV but alpha scattering experiments reported it to be at $80 A^{-1/3}$ MeV. In our recent Ce experiment, we report no positive evidence that it should be at $80 A^{-1/3}$ MeV. Furthermore, the $50 A^{-1/3}$ MeV resonance seems to be quadrupole oscillation of the excess neutrons in heavy nuclei. Thus the monopole mode remains an unsolved problem in our view.

Conference Presentations: H. Hass, E. E. Hunter, D. H. Meyer, G. Pozinsky, R. Pitthan, J. N. Dyer, F. R. Buskirk, "High Energy Giant Resonances in Ce", American Physical Society, Spring Meeting, Washington, D. C., April 1978,

presented abstract, published in Bull. Am. Phys. Soc. 23, 506 (1978).

R. Pitthan and F. R. Buskirk, "On the Monopole Breathing Mode in Nuclei", American Physical Society, Spring Meeting, Washington, D. C., April 1978, presented abstract, published in Bull. Am. Phys. Soc. 23, 506 (1978).

J. S. Beachy, F. R. Buskirk, S. J. Kowalick, and R. Pitthan, "Giant E3 Strength in ^{58}Ni and ^{60}Ni ", American Physical Society, Fall Nuclear Physics Meeting, Rochester, NY, November 1977, presented abstract, published in Bull. Am. Phys. Soc. 22, 1022 (1978).

F. R. Buskirk, J. N. Dyer and R. Pitthan, "Systematics of Giant E3 Strength in Heavy Nuclei from (e, e') ", American Physical Society, Fall Nuclear Physics Meeting, Rochester, NY, November 1977, presented abstract, published in Bull. Am. Phys. Soc. 22, 1022 (1978).

Publications:

R. Pitthan, H. Hass, D. H. Meyer, J. N. Dyer, F. R. Buskirk, "E1 Formfactor and the Existence of a Breathing Mode at $80 \text{ A}^{-1/3} \text{ MeV}$ in Heavy Nuclei", Physical Review Letters, Vol. 41, 19, (1978) p 1276.

R. Pitthan, F. R. Buskirk, J. N. Dyer, E. E. Hunter and G. Pozinsky, "Distribution of D2 Strength in ^{28}Si Below 50 MeV Excitation Energy", Physical Review. Accepted but not yet in print.

R. Pitthan, H. Hass, D. H. Meyer, F. R. Buskirk and J. N. Dyer, "Investigation of E0, E1, E2, E3 and E4 Giant Resonances in the N=82 Nucleus ^{140}Ce Between 4 and 48 MeV Excitation Energy with Inelastic Electron Scattering", Physical Review, Pending.

- Title:** Laser Produced Plasmas
- Investigators:** A. W. Cooper, Professor and F. Schwirzke, Associate Professor of Physics and Chemistry
- Sponsor:** Foundation Research Program (6.1)
- Objective:** In this continuing project the interaction is investigated between intense laser pulses and targets. The dynamics of the laser produced plasma and self-generated magnetic fields are studied.
- Summary:** Further experimental evidence has been found that magnetic fields are generated in the steepened front of a fast moving plasma plume which is interacting with a background plasma. A laser produced plasma expands in z-direction normal to the target surface with a velocity of about 10^7 cm/sec. If the laser produced plasma flows into a photo-ionized background plasma of sufficient density, shock heating at the front will produce a temperature gradient in z-direction. Magnetic fields in azimuthal direction are then generated long after laser shut-off by the cross product of the radial density gradient and the electron temperature gradient in z-direction. The location of the peak magnetic field coincides with the steepest gradient in the shock front. Very basically, spontaneous magnetic fields should be generated whenever a shock is produced by a plasma streamer.
- Conference Presentations:** A. W. Cooper and F. Schwirzke, "Spontaneous Magnetic Field Generation in Shock Waves", 19th Annual Meeting of the Division of Plasma Physics of the American Physical Society, 7-11 November 1977, Atlanta, GA.
- Thesis Directed:** C. Parlar, "Self-Generated Magnetic Fields in Laser Produced Shock Waves", Master's Thesis, December 1978.

Title: Generation, Propagation, and Detection of Flexural Waves in Beams

Investigators: A. B. Coppens, Associate Professor of Physics
O. B. Wilson, Professor of Physics

Sponsor: Naval Weapons Center, Code 3314,
Myren Iverson

Objective: (1) To investigate the coupling of acoustical energy in the form of longitudinal and transverse waves from a sound source into a steel beam and thence to the detector.
(2) To design sample transducers for the generation and detection of this energy.

Summary: Theoretical studies of the properties of thin plates and beams revealed that for the frequencies of interest and beams of the dimensions of interest, the lowest order flexural waves would be the dominant contributions to the sound field in the beam, and for the antisymmetric flexural wave (a_0) there would be little dispersion. Experimental studies revealed that for all placements of source and detector transducers, the above was observed to be the case, with the a_0 mode the most significant.
A number of small piezoelectric ceramic transducers, designed to serve best as projectors, were constructed. Some of these were used in the experiments mentioned above. All were given to the sponsor for possible use in future tests or experiments.

Publications: A Technical Report is in preparation.

Title: Transmission of Acoustic Energy from a Fluid Wedge Into a Fast Bottom

Investigators: A.B. Coppens, Associate Professor of Physics
J.V. Sanders, Associate Professor of Physics

Sponsor: Naval Ocean Systems Center, E.P. Copper, Code 013, San Diego, CA

Objective: To determine the acoustical properties of the highly-collimated beam of sound that is transmitted into a bottom whose speed of sound exceeds that of the overlying water layer when the depth of the water layer decreases below that necessary to maintain the propagation of sound in the water layer. Specifically, this deals with the detection of low frequency sound transmitted up the continental shelf which is transmitted into the bottom when it encounters sufficiently shallow water depths.

Summary:

Theoretical: Using a combination of ray theory and normal mode theory, a simple model for the pressure amplitude and phase at the interface between the wedge layer and the bottom was obtained. Using these results, the method of Green's functions and the method of stationary phase, an approximate expression was obtained for the properties of the beam transmitted into the bottom. Comparison with experiment revealed qualitative agreement, but not quantitative. This simple model was then deemed inadequate and it was decided to obtain the pressure and phase along the bottom by application of the method of images. Computer programs to perform this calculation were designed, one for infinite source distance from the apex of the wedge, another for finite source distance. These programs have been designed, and exhaustive tests are being conducted by comparing the results of these programs with direct calculations for a number of special,

simple cases. Upon conclusion of these tests, the predictions of the computer programs will be compared directly with the experimental measurements of the pressure amplitude and phase along the interface. At the same time, we are attempting to reduce the method of images formulation to obtain simple analytical expressions which, although approximate, will be more accurate than the first simple model discussed above.

Experimental:

Measurements made with a wedge of water overlying a small tank of brine solution verified the existence of a narrow beam of sound that enters the bottom at the predicted point. However, the angle of depression and width of the beam were not quite in agreement with the predictions of the theory. Measurements were ambiguous because of the presence of unexplainable interferences that distorted the beam shape making measurements of the depression angle and beam width difficult. Therefore, a new experimental facility was constructed in which a wedge of silicon oil was suspended in a large tank of water. The interferences still existed but it was possible to show that they were not due to reflections from the tank walls and were, indeed, characteristic of wedge propagation. Measurements were then taken of the pressure amplitude and phase along the interface; these will be compared to the predictions of our new image theory program.

Conference Presentations:

J.V. Sanders, A.B. Coppens, G.B. Netzorg, "Experimental Study of the Propagation of Sound Into a Fast Bottom from an Overlying Fluid Wedge," 95th Meeting: Acoustical Society of America, Providence, RI, 16-19 May 1978, Presented. Abstract Published in The Journal of the Acoustical Society of America, Vol. 63, Suppl. No. 1, Spring 1978.

J.V. Sanders, "The Experiment: Transmission of Acoustic Waves Into a Fast

Fluid Bottom from a Converging Fluid Wedge," Workshop on Seismic Propagation in Shallow Water, NRL, Washington, DC, 6-7 July 1978, Presented full paper in Proceedings.

A.B. Coppens, "Theoretical Study of the Propagation of Sound into a Fast Bottom From an Overlying Wedge," 95th Meeting: Acoustical Society of America, Providence, RI, 16-19 May 1978, Presented. Abstract, Published in J. Acoust. Soc. Am. 63, Suppl. 1, Spring 1978, S11.

A.B. Coppens, "Theoretical Study of the Propagation of Sound into a Fast Bottom From an Overlying Fluid Wedge," Workshop on Seismic Propagation in Shallow Water, NRL, Washington, DC, 6-7 July 1978, Presented full paper in Proceedings.

Thesis Directed:

G.B. Netzorg, "Sound Transmission from a Tapered Fluid Layer into a Fast Bottom," Master's Thesis, December 1977.

Title: Optical Extinction in the Marine Boundary Layer

Investigators: E. C. Crittenden, A. W. Cooper, Professors of Physics and Chemistry; E. A. Milne, G. W. Rodeback, R. L. Armstead, Associate Professors of Physics and Chemistry

Sponsor: Naval Sea Systems Command, PMS-405

Objectives: Development of measurements techniques and measurement of the optical extinction due to fog and aerosols over the ocean, concurrently with aerosol particle size distribution and meteorological measurements.

Summary: Multiwavelength extinction measurement techniques have been developed for long path (to 20 km) land-based over-ocean ranges available at Monterey. Shorter path techniques have also been developed which have the capability of dealing with the motion involved in shore-to-ship measurements, as well as slant-path measurements from a kytoon to a ship. Preliminary measurements have been made off San Nicolas Island and from Pt. Pinos to Marina in Monterey. These have been made in conjunction with micro-meteorological measurements and nephelometer measurements on the research vessel Acania. Joint experiments have also been carried out with the Naval Ocean Systems Center, San Diego, in which they provided measurements of particle size spectra, measured in an instrumented aircraft flown along the optical path. The experiments are aimed at determining the cause of serious disagreement between predicted extinction based on particle size distribution measurements and directly measured values.

Publications: E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead, "Photo and Electro-Optics in Range Instrumentation", Society of Photo-Optical Instrumentation Engineers, 134, March 1978, pp 34-37.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead, "Optical Properties of the Atmosphere", Society of Photo-Optical Instrumentation Engineers, 142, March 1978, pp 130-134.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead, "Spot Broadening and Wander in Turbulence", abstract published by Lincoln Laboratory, July 1978.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead, "Long Path, Shipboard, and Slant Path Extinction Measurements", abstract published by Lincoln Laboratory, July 1978.

E. C. Crittenden, A. W. Cooper, E. A. Milne, G. W. Rodeback, R. L. Armstead and S. Kalmbach, "Optical Extinction in the Marine Boundary Layer", Technical Report NPS 61-78-006, in preparation.

**Conference
Presentation:**

E. C. Crittenden, "Long-Path, Shipboard, and Slant-Path Extinction Measurements", presented at High Energy Laser Review Group Meeting, Washington, D. C. 18-20 March 1978.

Theses Directed:

Robie L. Williams, "Shipboard Stabilization of Optical Systems", Master's Thesis, June 1978.

Daniel G. Henderson, "An Experiment to Measure Slant Path Extinction in the Marine Boundary Layer", Master's Thesis, June 1978.

Nusret Guner, "High Resolution Optical Transmittance Calculations Over Monterey Bay", Master's Thesis, December 1978.

R. A. Molland, "Procedure for Statistical Analysis of Single Scan Modulation Transfer Functions for Optical Transmission in the Marine Boundary Atmosphere," Master's Thesis, December 1978.

Title: Development of Ray-Tracing Algorithms for Underwater Acoustic Ranges

Investigator: Harvey A. Dahl, Assistant Professor of Physics

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, WA

Objective: Continued development and testing for computer programs for more accurate determination of the position of sound sources in an underwater acoustic range.

Summary: Continuing study of the improved NPS algorithms for range tracking has shown that calculation of angle of entry into the tracking array has accuracy limitations strongly dependent on the speed of sound profile. For profiles with form approaching constant gradient the NPS entry angle algorithm is superior to the old algorithm. However, for profiles deviating significantly from linearity both old and new algorithms suffer inherent errors. These can only be reduced by iterative techniques which model the sound speed profile more exactly but are prohibitively expensive in computer time. An algorithm for the iterative procedure has been developed. Furthermore, the entry angle errors have been shown to be partly compensated by array survey techniques now in use. Ray trace-back has also been shown to be critically dependent on accuracy of sound speed determination at the array center (start of trace-back through the refractive medium) and in the deeper water where the ray elevation angle is small. In general, precision of position determination, especially in the depth coordinate, has been shown to depend strongly on the precise knowledge of sound speed profiles throughout the acoustic range. It is suggested that depth telemetry techniques be invoked to reduce the depth error if at all possible.

Publications: Technical report in progress. Brief unpublished report has been made to sponsor.

Presentations: Certain of the results were presented to the sponsor in a meeting in Keyport during the period 22 to 24 March 1978 and during my extended stay at Keyport from 10 July to 1 September 1978.

Title: Evaluation of Noise Characteristics of Pneumatic Hand Tools

Investigators: Harvey A. Dahl, Assistant Professor of Physics
James V. Sanders, Associate Professor of Physics
Karlheinz E. Woehler, Professor of Physics

Sponsor: Naval Air Rework Facility, San Diego, CA

Objective: To determine the absolute noise level and noise spectrum of certain noisy hand tools and to develop a method of comparing them with newer tools and with health standards.

Summary: This is a new effort which is still in the planning and instrumentation stage. Apparatus is being assembled and computer programs for automated data taking are being written.

Title: Classical Trajectory Studies of Low Energy Ion Impact Mechanisms on Clean and Reacted Single Crystal Surfaces

Investigators: Don E. Harrison, Jr., Professor of Physics with B.J. Garrison and N. Winograd, Purdue University

Sponsor: None (Follow-on of Previously Begun Program Supported by NPS Foundation Program). (Collaborators had support at LBL).

Objectives: Continue study of the effects produced when ions bombard clean and chemically reacted single crystal metal surfaces to understand mechanisms and coordinate with experimental investigations.

Summary: Classical trajectory simulations have developed to the point that it is feasible to model the cascade produced by an ion impact event. The ability to follow each individual atom in the cascade leads naturally to pictorial interpretations of a single sputtering event. Statistical analysis of data produces numbers which can be directly compared to the experimental data. The model computations are done using single crystal targets oriented to expose the low index surfaces. They indicate that the ejection mechanisms are very sensitive to the target face exposed. For example, the atom struck by the ion is often emitted from the (110) face, but very rarely from the (100) and (111) faces. An overwhelming majority of the ejected atoms come from the surface layer. Molecular recombination mechanisms are orientation sensitive. The multimer yield ratios agree with data from experiments on Ni surfaces. Investigations in progress at this time demonstrate that oxygen atoms can be placed on the target surface without unduly complicating the computations or greatly increasing the computation time. We studied oxygen reacted copper surfaces. The pure

metal simulations produce "spot patterns", a representation of the angular dependence of the emission of target atoms, which are in excellent agreement with corresponding experimental patterns. The adsorbate atoms were placed in a $c(2 \times 2)$ array above the Cu(100) surface plane. The angular distributions calculated from the three candidate registries are quite different, particularly when only the high energy sputtered atoms are collected. Thus it appears that a collaboration between simulation and angular dependent SIMS can determine the registry of regular adatom structures on metal surfaces.

Publications:

D.E. Harrison, Jr., P.W. Kelly, B.J. Garrison and N. Winograd, "Low Energy Ion Impact on Single Crystal Surfaces," *Surface Science*, 76, (1978) pp 311.

B.J. Garrison, N. Winograd and Don. E. Harrison, Jr., "Formation of Small Metal Clusters by Ion Bombardment of Single Crystal Surfaces", *J. of Chem. Phys.* 69, (1978) pp 1440.

N. Winograd, B.J. Garrison, and Don. E. Harrison, Jr., "Angular Distribution of Ejected Particles from Ion Bombarded Clean and Reacted Single Crystal Surfaces", *Phys. Rev. Letters* 41, (1978) pp 1120.

Conference Presentations:

D.E. Harrison, Jr., Invited Paper, "Computer Simulation of the Sputtering of Clusters", Wehner Retirement Seminar on Sputtering and Surface Characterization, Minneapolis, MN, 15 May 1978.

B.J. Garrison, D.E. Harrison, Jr. and N. Winograd, "Low Energy Ion Impact Phenomena on Single Crystal Surfaces", 1978 IEEE International Conference on Plasma Science, Monterey, CA, 15-17 May 1978.

D.E. Harrison, Jr., B.J. Garrison and N. Winograd, Invited Paper, "Computer Simulation of Sputtering," American Society for Mass Spectrometry, St. Louis, MO, 28 May - 2 June 1978.

D.E. Harrison, Jr., B.J. Garrison, and N. Winograd, Invited Paper, "Computer Simulation of Sputtering", Second International Workshop: Inelastic Ion-Surface Collisions, Hamilton, Ontario, 14-16 August 1978.

Title: Geomagnetic Field Fluctuations on the Ocean Floor

Investigators: O. Heinz, Professor of Physics and Chemistry and P. Moose, Visiting Professor of Physics and Chemistry

Sponsor: Foundation Research Program (6.2)

Objective: The objective of this project is to obtain improved long term data and interpretations of the electromagnetic noise on the ocean floor. By using a combination of total field magnetometers and ULF/ELF receivers it is planned to cover the frequency range from .001 to 1000 Hz.

Summary: Measurements of geomagnetic field fluctuations in the frequency range 0.1 to 10 Hz were carried out on land and measurements below 0.1 Hz are currently underway using a Cs vapor optically pumped magnetometer at La Mesa Village. Tests have been carried out in Monterey Bay to a depth of about 100 m using magnetic loop antennas designed to operate in the 50 to 1000 Hz frequency range. In addition, tests on the deployment of long electric antennas were carried out in Monterey Bay as well as a study of various electrode materials in sea water done in the laboratory.

During the next year we are planning to combine and expand these measurements by the use of an improved loop antenna (now under construction) and ocean floor measurements using the magnetometer.

Theses Directed: J. M. Barry, "Power Spectra of Geomagnetic Fluctuations Between 0.1 and 10 Hz", Master's of Science Thesis, June 1978.

L. Dearth, "Investigation of Electrode Materials for Low Frequency Antennas in Seawater", Master's of Science Thesis, December 1978.

Title: Spectroscopic Data Center Compilation of Atomic Energy Levels

Investigator: Raymond L. Kelly, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: To produce a useful, comprehensive, and semi-critical compilation of atomic energy levels, based on publications listing spectrum lines. The compilation is to be stored on magnetic tape, in order to be available to a large community of users, and is to be updated regularly on a continuing basis.

Summary: The compilation has been completed for the first 18 elements, Hydrogen through Argon, for all stages of ionization. Such information makes possible the classification of unidentified lines from plasma sources and in solar spectra, as well as the prediction of other lines (valuable in laser physics).

Publication: Raymond L. Kelly and Don E. Harrison, Jr., "Ionization Potential of Fe XVII in the Neon Isoelectronic Sequence, Revised Value", Atomic Data and Nuclear Data Tables 19, 301-303 (1977).

Title: Spectroscopic Data Center Compilation of Near Ultraviolet Spectra

Investigator: Raymond L. Kelly, Professor of Physics

Sponsor: National Aeronautics and Space Administration, Dr. Albert Boggess, Code 683, Goddard Space Flight Center, Greenbelt, MD.

Objective: To produce a critical compilation of long wavelength ultraviolet lines (wavelengths 2000-3000 Angstroms) in support of space exploration and solar physics, maintaining a current compilation on continuous basis. The work is based on publications in the open literature.

Summary: The initial compilation of 30,000 lines, from the first 36 elements, has been completed. It has been stored on magnetic tape and submitted for publication as a NASA Special Publication. Work has started on adding the classifications to each line as an extension of the initial compilation. This continuing project will be completed in three years. Included in the final compilation will be (for each spectrum line) wavelength, intensity, classification, and energy level for both the upper and lower state in the transition.

Publications: The initial compilation has been submitted to GSFC for publication, details to be handled by their personnel.

Title: Spectroscopic Data Center Compilations
of Vacuum Ultraviolet Spectra

Investigator: Raymond L. Kelly, Professor of Physics

Sponsors: Department of Energy, Dr. Don Priester,
Applied Plasma Physics Program, Office
of Fusion Energy

National Aero and Space Administration,
Dr. J.D. Bohlin, Code ST-5, Washington,
D.C.

Objective: Preparation of a critical compilation of
atomic spectrum lines with wave-lengths
below 2000 Angstroms, for the first 36
elements. This is a continuing project.

Summary: Computer-based files are prepared con-
taining the wavelength, intensity, and
classification for all lines observed
in solar or terrestrial sources. A com-
plete file of atomic energy levels is
maintained for calculation of wavelengths
of predicted transitions. These wave-
lengths are critically compared with
those reported in the literature and in
unpublished communications. A new com-
pilation has been completed for the first
18 elements and stored on magnetic tape,
preparatory to publication. Completion
of the final compilation is scheduled
for 1981.

Publication: Raymond L. Kelly and Don E. Harrison, Jr.,
"Ionization Potential of Fe XVII in the
Neon Isoelectronic Sequence, Revised
Value", Atomic Data and Nuclear Data
Tables 19, 301-303, 1977.

Title: Ocean Parameters Affecting Sonar Propagation

Investigator: H. Medwin, Professor of Physics

Sponsor: Office of Naval Research

Objective: To determine those parameters of the ocean which affect sound propagation.

Summary: During FY 78: We employed the large physical scale model of the ocean (Ocean Acoustic Wave Facility, OAWF) to prove that frequency selection is a very effective way to decrease fading of surface reflected sonar signals. A patent application has been filed by ONR, San Francisco (Navy Case No. 62580).

OAWF Studies also showed the feasibility of using a one hydrophone technique for locating marine mammals in shallow water and for removing the reverberation of the shallow water environment; the process has been called deverboration, and a patent application has been filed by ONR, San Francisco (Navy Case No. 62582) for this concept.

Our computer model study, for the first time, explained the acoustical shadowing of surface backscattered underwater sound at near grazing incidence. A joint publication with J. C. Novarini gives details of the research (see below). Oral presentations of these three aspects of the total program were given at meetings of the Acoustical Society of America.

Publications: J. C. Novarini and H. Medwin, "Diffraction, Reflection and Interference during Near-Grazing and Near-Normal Ocean Surface Backscattering", Journal of Acoustics Society of America, 6(1), pp 260-268, July 1978.

H. Medwin, "Backscattering from Noise Barriers", Noise Control Engineering, 1979 (pending publication).

Conference

Presentations:

R. Bostian and H. Medwin, "Single Hydrophone Technique for Obtaining Spectral Source Levels of Marine Mammals in Coastal Waters", presented at the Meeting of Acoustical Society of America, Miami Beach, Florida, December 1977.

R. B. Shields, Jr. and H. Medwin, "Inter-Frequency Correlation of Specularly Scattered Underwater Sound", presented at the Meeting of Acoustical Society of America, Miami Beach, Florida, December 1977.

J. C. Novarini and H. Medwin, "Relative Contributions of Diffraction, Facet Reflections, and Interference to the Field Backscattered by a Randomly Rough Surface" presented at the Meeting of Acoustical Society of America, Miami Beach, Florida, December 1977.

Theses Directed: R. B. Shields, Jr., "Inter-Frequency Correlation of Specularly Scattered Underwater Sound", Master's Thesis, December 1977.

R. Bostian, "Single Hydrophone Technique for Obtaining Spectral Source Levels of Marine Mammals in Coastal Waters", Master's Thesis, December 1977.

Title: Geomagnetic Field Fluctuations on the Ocean Floor

Investigators: Paul Moose, Adjunct Professor of Physics and Chemistry, Otto Heinz, Professor of Physics and Chemistry

Sponsor: Office of Naval Research, Code 463

Objective: Obtain improved long term data and interpretation of electromagnetic noise and background on the ocean floor. Develop instrumentation required for coherent measurements in the .001 Hz to 100 Hz frequency range in water depths from 50 to 5000 meters.

Summary: Measurements of geomagnetic field fluctuations in the frequency range 0.1 to 10 Hz were carried out on land near Monterey using a C_s vapor total field magnetometer. Tests were carried out in the 100 to 1000 Hz range using a 1 m² loop antenna on the floor of Monterey Bay. Results of these tests have led to new antenna designs and electronics for the C_s vapor magnetometer discriminator. Preliminary findings identify magneto-hydrodynamic effects as important sources of ULF EM-fields in the sea.

Theses Directed: John Barry, "Power Spectra of Geomagnetic Fluctuation", Master's Thesis, June 1978.

L. Dearth, "Deep Water Detection of Very Low Frequency E-M Fields in the .1 to 10 Hz Range", Master's Thesis, December 1978.

M. Clayton, "Geomagnetic Field Fluctuation (Monterey, California) and Wave Induced Magnetic Fields", expected to graduate June 1979.

E. Chaffee, "Geomagnetic Fluctuation Measurements on the Floor of Monterey Bay", expected to graduate December 1979.

Title: Thermochemical Calculations Related to Internal Blast

Investigators: R.A. Reinhardt, Professor of Chemistry
G.F. Kinney, Distinguished Professor Emeritus, K.J. Graham, Chemist, Physics and Chemistry Department

Sponsor: Naval Weapons Center, China Lake, CA, Mr. John Pearson, Detonations Physics Division, Code 383.

Objective: Computation of hydrostatic pressure resulting from explosions in confined spaces

Summary: The study of internal blast effects is of great importance in weapons research and in the determination of the mechanism of damage effects in compartmental explosions. A program has been developed for a desktop computer to compute product yields, temperatures and overpressures for the adiabatic combustions of nitrogenous organic fuels and explosives, alone or mixed with magnesium, in air. Results have been computed for a wide variety of explosives/fuels over a two decade range of composition and of fuel-to-metal ratio.

Publication: Reinhardt, R.A., "Reactive Metals in Internal Explosives: The Combustion of Magnesium in Air", Naval Weapons Center Report, February 1978, 14 pp.

Title: Measurement of Acoustic Source Levels in a Reverberant Environment

Investigator: J.V. Sanders, Assistant Professor of Physics

Sponsor: Research and Engineering Department, Naval Undersea Warfare Engineering Station, Keyport, WA

Objective: To study methods of obtaining source levels from measurements made in reverberant environments when the location of the source is known.

Summary: Acoustic measurement was performed for the purpose of calculating the noise radiated by a source in a reverberant environment. A deconvolution technique was tested as a way to extract the original signal from the signal contaminated by reverberation. In order to determine the transfer function of the medium, a linear frequency modulated (chirp) pulse was used, with pulse length of 1 second and frequency shift from 50 Hz to 4 kHz. The result, obtained using a statistical stationary mathematical approximation and for a motionless omni-directional source, shows the feasibility of applying the deconvolution technique to this problem. While there is indicated a feasibility of using this technique for a fixed point source, the problem of applying this signal processing approach to the extended, moving source is a very formidable one. This fact plus the fact that there was no follow-on student involvement in this problem area resulted in deferring continued work on this task. Work was continued on completing the interpretation and documentation of the results of the acoustic reverberation experiments conducted earlier in Dabob Bay. The report of this work should be published late in 1978.

Thesis Directed: G.H. Santillan, "Measurement of Radiated Noise in a Reverberant Environment," Master's Thesis, December 1977.

Title: Marine Boundary Layer Study: MABLES-WC

Investigator: Gordon Schacher, Associate Professor of Physics and Chemistry

Sponsor: Foundation Research Program (6.1)

Objective: Study dynamics of the West Coast marine inversion. Relate the properties of the inversion to the mean flow and surface layer properties, principally, the surface fluxes.

Summary: A three week research cruise was conducted aboard the R/V ACANIA off the coast of California. Data was gathered to allow determination of surface layer fluxes, stability, inversion height, and the mean flow. This cruise was in conjunction with similar efforts by another ship, two aircraft and several ground stations. All data has been obtained and is in the process of being correlated for the various platforms.

Title: At Sea Studies of the Marine Boundary Layer in the Los Angeles Air Basin

Investigator: G. E. Schacher, Associate Professor of Physics and Chemistry

Sponsor: California Air Resources Board

Objective: To measure surface layer fluxes of heat and momentum and mean atmospheric conditions over water in the Los Angeles air basin. Relate these quantities to the marine layer mixing rates in order to parameterize the boundary properties of current air basin pollution models.

Summary: The experimental aspects of the program were completed during FY 77. Subsequent calculations on comparison with tracer studies show that mixing in the marine boundary layer is accomplished by large scale processes. The mixing can be correctly measured from surface fluxes and the height of the temperature inversion. Mixing rates are very rapid, on the order of 10's of minutes. Near the shore, the mixing rate shows considerable diurnal variation.

Publications: G. E. Schacher, C. W. Fairall, K. L. Davidson and T. M. Houlihan, "Experimental Investigation of the Marine Boundary Layer in Support of Air Pollution Studies in the Los Angeles Air Basin", Technical Report, NPS 61-78-002, February 1978.

Title: Laser Induced Acoustic Pulses in Water

Investigator: F. Schwirzke, Associate Professor of Physics and Chemistry

Sponsor: Foundation Research Program (6.1)

Objective: In this new project the generation of sound by laser pulses, the coupling efficiency, and the sound spectrum were studied.

Summary: The interaction of Q-switched neodymium glass ($1.06 \mu\text{m}$) laser radiation with distilled water for the purpose of creating acoustic pulses was investigated. Average laser output was 80 MW. Two sound generation mechanisms were studied: thermoelastic expansion and dielectric breakdown. The thermoelastic process was shown to produce a spherically expanding pressure wave with a fundamental frequency of 50 kHz. Maximum sound pressure levels of 65 dB (re 1 μbar) were observed with an energy coupling efficiency on the order of $10^{-6}\%$. The frequency of 200 kHz produce sound pressure levels near 120 dB (re 1 μbar). The coupling efficiency was approximately 1%.

Additionally, Schlieren system shadowgraphs revealed the formation of a dense plasma bubble in the breakdown region. Peak pressures within the bubble were calculated to be as high as 450 k bars. Maximum shock velocities of $8.5 \times 10^5 \text{ cm/sec}$ were measured from the shadowgraphs.

Theses Directed: D. A. Armstrong, "Laser Induced Acoustic Pulses in Water", Master's Thesis, December 1978.

J. H. Cocowitch, "Laser Induced Acoustic Pulses in Water", Master's Thesis, December 1978.

Title: LISA, Laser Induced Surface Analysis

Investigators: F. Schwirzke, Associate Professor of Physics and Chemistry and R. J. Taylor, Department of Physics, University of California, Los Angeles

Sponsor: Department of Energy

Objective: In this joint project a new laser probing technique has been developed to determine the concentration of loosely bound impurities present on the surface at any time during a tokamak discharge.

Summary: Impurities released by plasma-surface interactions play a major role in influencing the performance characteristics of many of today's magnetic fusion machines, especially tokamaks. Sputtering leads to an influx of high-Z impurities from the walls and limiter. Not all of the sputtered metal atoms, when being redeposited from the plasma onto the wall, will be recaptured on lattice sites where they are tightly bound to the crystal structure. Loosely bound metal atoms are probably contributing to the observed, higher than expected, high-Z impurity concentrations in tokamaks. Knowledge of the surface conditions during tokamak discharges is most important for a better understanding of processes related to plasma-surface interactions, discharge cleaning, and impurity transport.

Conventional surface analytic techniques like auger spectroscopy, low energy electron diffraction, secondary ion mass spectroscopy, etc., have been used to measure after many discharges the integrated accumulation of wall and limiter materials on clean test surfaces. These techniques are not applicable during the discharge and time resolved measurements are not possible.

Now a new laser probing technique has been developed to determine the concentration of loosely bound impurities present on the surface at any time during the tokamak discharge. Surface

spot heating by a laser pulse induces desorption of loosely bound species. Coincident spectroscopic measurements of the locally increased impurity radiation show that species and amount of impurities which were present on the surface. The first laser shot onto a new surface produces a large impurity influx into the plasma while consecutive laser shots produce much smaller signals. These results reveal the existence of loosely bound chromium and iron on tokamak surfaces.

Publications:

F. Schwirzke, L. Oren, S. Talmadge and R. J. Taylor, "Laser-Induced Desorption of Impurities from the Macroter Tokamak Walls", Physical Review Letters, 40, 18, pp 1181-1184, 1978.

L. Oren, F. Schwirzke and R. J. Taylor, "Phenomenology of Metal Influx in Macroter", Journal of Nuclear Materials, Vol 76 and 77, pp 412-417, 1978.

L. Oren, F. Schwirzke and R. J. Taylor, "Measurements of Wall Impurity Concentrations During Tokamak Discharges", Diagnostics for Fusion Experiments, Pergamon Press Ltd, Oxford, United Kingdom, December 1978.

F. Schwirzke, L. Oren and R. J. Taylor, "Measurements of Wall Impurity Concentrations During Tokamak Discharges", Technical Report, NPS 61-79-002, August 1978.

L. Oren, F. Schwirzke and R. J. Taylor, "Phenomenology of Metal Influx in Macroter", published by the Center for Plasma Physics and Fusion Engineering, University of California, Los Angeles, Technical Report, PPG-355, May 1978.

T. S. Hsu and F. Schwirzke, "Tokamak Impurity Report", Department of Energy Technical Report, ET-0001, December 1977.

**Conference
Presentations:**

L. Oren, F. Schwirzke and R. J. Taylor, "Phenomenology of Metal Influx in Microtor/Macroto Tokamaks", presented at the 3rd International Conference on Plasma Surface Interactions in Controlled Fusion Devices, held at Culham Laboratory, Abingdon, Oxfordshire, United Kingdom, 3-7 April 1978.

L. Oren, F. Schwirzke, S. Talmadge and R. J. Taylor, "Diagnostics of Impurities on Tokamak Surface by Laser Induced Desorption", presented at the Second Topical Conference on High Temperature Plasma Diagnostics, Santa Fe, New Mexico, 1-3 March 1978.

F. Schwirzke and R. J. Taylor, "Observation of Radiative Continua from High-Z Impurities in a Tokamak Plasma", presented at the Twentieth Annual Meeting, Division of Plasma Physics, American Physical Society, Colorado Springs, Colorado, 30 October - 3 November 1978.

Thesis Directed:

Z. W. Hwang, "Laser Induced Evaporation from Stainless Steel Surfaces", Master's Thesis, December 1978.

Title: Light Trapping in Thin Liquid Films

Investigator: William M. Tolles, Professor of Chemistry

Sponsor: Un-sponsored

Objective: The propagation of light in a thin fluid layer adjacent to a reflecting medium is to be characterized; applications of this effect for chemical and material analysis are being investigated.

Summary: A new apparatus designed and constructed at NPS allows light to be trapped in a thin uniform fluid layer adjacent to a reflecting wall. A peculiar and unexpected hopping of a transmitted laser beam is observed. A model is developed utilizing the Navier Stokes equation in conjunction with diffusion effects in order to explain this effect. The overall phenomenon has possible advantages for the analysis of electrode processes by optical means. Oxidation-reduction phenomena have been observed utilizing the apparatus. The signal-to-noise characteristics of these spectroscopic techniques are being determined.

Publications: W. M. Tolles and J. C. Devlin, "A Novel Light Trapping Experiment in Fluid Media", in American Journal of Physics (pending).

Thesis Directed: J. D. Devlin, "Light Trapping in Thin Liquid Films with Electrochemical Applications", Master's Thesis, June 1978.

Title: Non-Line-of-Sight Communication in the Middle Ultraviolet

Investigator: William M. Tolles, Professor of Chemistry

Sponsor: Naval Weapons Center

Objective: The propagation of laser beams through scattering and absorbing media is modelled and characterized. The range of communication when utilizing multiple scattered photons is deduced.

Summary: Multiple scattering and absorption effects have been simulated with a Monte Carlo routine written for this purpose. Characteristics of currently available lasers, of typical atmospheric parameters, of state-of-the-art filters, and present day detectors are incorporated in order to deduce performance values. Middle-UV performance suggests the possibility of utilizing this new communication channel for relatively short range communication, including non-line-of-sight geometries. Propagation characteristics of blue/green lasers through clouds have been characterized, with particular emphasis on pulse spreading characteristics.

Publications: W. M. Tolles and D. M. Junge, "Non-Line-of-Sight Electro-optic Laser Communications in the Middle Ultraviolet", Technical Report NPS-61-77-001, December 1977.

Conference Presentations: W. M. Tolles and D. M. Junge, "Model of Non-Line-of-Sight Communication with Lasers in the Middle UV", presented at the Seventh Tri-Service Ultraviolet Technology Meeting, Naval Research Laboratory, Washington, D.C., January 25, 1978.

W. M. Tolles and M. A. Millbach, "Computer Simulation of Light Propagation Through Scattering Media", presented at the Blue/Green Cloud Propagation Workshop, Naval Ocean Systems Center, San Diego, California, 21-23 March 1978.

Thesis Directed:

Miles A. Millbach, "Computer Simulation of Light Propagation Through a Scattering Medium", Master's Thesis, June 1978.

The propagation of laser beams through scattering and absorbing media is modeled and characterized. The range of communication when utilizing multiple scattered photons is determined.

Multiple scattering and absorption effects have been simulated with a Monte Carlo technique written for this purpose. Characteristics of currently available lasers, of typical atmospheric parameters, of state-of-the-art filters, and present day detectors are incorporated in order to obtain performance values. Middle-UV performance suggests the possibility of utilizing this new communication channel for relatively short range communication, including non-line-of-sight geometries. Propagation characteristics of distributed lasers through clouds have been characterized, with particular emphasis on pulse spreading characteristics.

W. M. Tolles and D. M. Lange, "Non-Line-of-Sight Electro-Optic Laser Communication in the Middle Ultraviolet", Technical Report WPT-61-77-001, December 1977.

W. M. Tolles and D. M. Lange, "Model of Non-Line-of-Sight Communication with Lasers in the Middle UV", presented at the Seventh Tri-Service Ultraviolet Technology Meeting, Naval Research Laboratory, Washington, D.C., January 13, 1978.

W. M. Tolles and M. A. Millbach, "Computer Simulation of Light Propagation Through Scattering Media", presented at the High Power Laser Propagation Workshop, Naval Ocean Systems Center, San Diego, California, 21-23 March 1978.

Title: The Scattering of Spherical Pulses By Slightly Rough Surfaces

Investigator: I. Tolstoy, Visiting Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: Develop closed-form solutions for the coherent multiple scattering of transient spherical waves from rough surfaces by using a new method of equivalent boundary conditions combined with the technique of normal coordinates.

Summary: Using a "small roughness" boundary condition due to Biot, which incorporates the effects of multiple scatter, one can obtain simple, closed-form solutions for the coherent scattering of transient spherical waves. Combining this boundary condition with the normal coordinate technique leads to explicit solutions for impulsive or other point sources above or on a rough, rigid plane, i.e., for both finite and grazing angles of incidence. This approach distinguishes naturally between two types of arrival: body- (or volume) waves and boundary-waves; the latter incorporate the backscatter. The boundary wave dies off rapidly with distance from the surface. But, parallel to the boundary, in the absence of attenuation, its amplitude decreases only as $r^{-1/2}$ so that for sufficiently large r , and for source and receiver at or near the surface, the boundary-wave will dominate the direct acoustic pulse arrivals. The methods and results of this paper can be extended to problems of scatter and diffraction of spherical pulses by rigid (or free) plane rough surfaces bounding stratified media or by rough objects of other shapes, e.g., spheres, cylinders, ellipsoids, etc. This theory, valid for wavelengths or pulsewidths long compared to the characteristic roughness dimensions, leads to results that are different from those of the usual perturbation techniques and have been verified experimentally by Medwin, et al.

Title: Acoustic Transducer Development

Investigator: O. B. Wilson, Jr., Professor of Physics and Chemistry

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, Washington, Mr. R. L. Marimon, Code 70

Objective: Conduct studies relevant to development of a 75 kHz transducer which may be suitable for use on the acoustic tracking ranges at Keyport.

Summary: The requirements of small size, high source level, broad beam width, good transient response and ability to survive operating acoustically unloaded for extended periods place severe demands on the tracking transducers. The approach here is to investigate the use of a flexural wave in a plate for the radiating element as a possible improvement, particularly for low drag vehicle shapes. A study of the effects of fluid loading on flexural wave speed shows that in designing a transducer which will operate near the critical coincidence frequency, the fluid loading has a prominent effect on wave speed. Preliminary experimental tests of theoretical calculations of radiation patterns from a clamped edge circular plate using existing models indicate that there is reasonably good agreement.

Conference Presentations: O. B. Wilson, Jr. and J. L. Jarvis, "Measurement of the Effects of Fluid Loading on the Dispersion of Flexural Waves in a Plate", presented at the Fall 1978 Meeting of Acoustical Society, Honolulu, Hawaii, 27 November - 1 December 1978. Also Abstract in Journal of the Acoustical Society of America.

Thesis Directed: J. L. Jarvis, "Experimental Investigation of the Effects of Fluid Loading on Flexural Waves in Plates", Master's Thesis, December 1977.

Title: Range Studies Program

Investigators: O. B. Wilson, Professor of Physics and D. B. Hoisington, Professor of Electrical Engineering

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, WA, Code 70, Mr. R. L. Marimon

Objective: This is a continuing program in which certain NPS Faculty and students engage in studies of problems of long-range concern and interest to the Naval Undersea Warfare Station (NUWES), primarily in areas of ship and underwater weapons testing and test ranges.

Summary: Eleven Faculty members from various departments and a number of officer students participated in work on a number of tasks. Titles of tasks and individual investigators were: A. B. Coppens, Theoretical Comparisons of Acoustic Ray Path Calculations Using Different Sound Speed Profile Models; H. Dahl, Development of Alternative Algorithms for Ray Trace Calculations; H. Titus, Kalman Filtering Applications of Range Tracking; A. Washburn, Simulation of a Kalman Filter; G. L. Sackman, Applications of Adaptive Acoustic Processing to Radiated Noise Measurement and Shallow Water Ranging; D. A. Stentz, Applications of Adaptive Acoustic Processing to Arrays; J. V. Sanders, Measurement of Acoustic Source Levels in a Reverberant Environment; O. B. Wilson, Development of Acoustic Transducers; J. B. Knorr, Electromagnetic Propagation Experiments; O. B. Wilson and G. L. Sackman, Acoustic Imaging Techniques; M. L. Cotton, Computer Algorithms and Displays; J. B. Tysver, Torpedo Path Estimation.

Publications: O. B. Wilson, "Annual Summary Report, Range Study Program", Project Report NPS-61-79-001PR, October 1978.

Title: X-Ray Emission from a Laser-Initiated Pinch

Investigators: K. E. Woehler, Professor of Physics
and F. Schwirzke, Associate Professor
of Physics

Sponsor: Defense Nuclear Agency

Objectives: In this new project the feasibility is studied to use a laser produced plasma as a preionized medium for a high power pulsed x-ray generator.

Summary: Intense x-ray emissions have been produced from the pinch of imploding wire arrays. The emitted radiation spectrum depends on the available generator power, the coupling of the energy into the plasma, the z-number of the wire material, the geometry, the mass and dynamics of the imploding wire array. To produce x-spectra of desired characteristics Z-values or Z-value combinations of alloys and wire diameters may be required which are not readily available or cannot be fabricated. Gas-puff experiments have been made successfully which widened the array of available materials, but are limited by the number of high-Z atoms containing complexes which are in gaseous state at temperatures which are compatible with these experiments. The investigators have therefore, proposed that vapor puffs which are generated by high intensity laser radiation interacting with solid electrode materials may be used instead of wire arrays or gas-puffs. This method would have the advantage that almost any kind of material composition could be used as target. In addition there would be a wide range of flexibility in the choice of the laser intensity and pulse length to vary mass and temperature of the ejected plasma in order to optimize the ejected plasma column for the main discharge. Experimental data obtained at NPS with a Q-switched Nd-glass laser of 2-10

Joule and 25 nsec pulse length with irradiances between $10^8 - 10^{11}$ W/cm² at the Al-target give evaporated masses of the order 0.2 mgr. It is further found that the ejection of the main plasma plume is preceded by a fast plasma jet which is believed to be due to absorption of the laser energy in the outer edge of the plasma plume near the critical density. These observations are in general agreement with the findings by other investigators and generally agree with the expectations from simple theoretical models.

DEPARTMENT OF ELECTRICAL ENGINEERING

The Electrical Engineering research program encompasses a variety of areas, including: (1) Electronic Warfare Systems; (2) Electromagnetics; (3) Acoustics and Electro-Optics; (4) Communications; (5) Toxic Vapor Level Detection/Recording; (6) Estimation and Control Systems; (7) Signal Processing; (8) Range Studies; (9) Solid State Devices; (10) Wave Propagation; and (11) Computers--Display/Graphics. The projects in each of these areas generally involve one or more faculty members working with several thesis students. A summary of the projects follows:

ELECTRONIC WARFARE SYSTEMS (EWS)

Professor David Hoisington and Professor Jeffrey Knorr continued their investigation of the ability of shipboard radars to detect key targets in the presence of Soviet jamming (*Project Click Jammer*).

Professor Harold Titus initiated or continued work in three EWS areas: (1) Mission planning for the EA 6-B jammer aircraft; (2) missile counter-measure techniques; and (3) scoring techniques for jamming effectiveness against non-command guided missiles (e.g. the SA6).

An adaptive beamformer for a random planar sensor array was investigated by Professor George Sackman. Two objectives are to improve passive bearing accuracy of hull mounted sonars at LOFAR frequencies or to improve HF-DF radio bearing estimation.

Infrared (IR) missile jamming is the subject of an investigation initiated by Professor John Powers.

Professor John Bouldry made an evaluation of the TPS-59 radar system performance in a jammed environment.

Professor Stephen Jauregui initiated an investigation of task force information and timeliness requirements for tactical over-the-horizon missile launching.

ELECTROMAGNETICS

Professors George Sackman, Otto Heinz (Physics/Chemistry) and R. Neagle Forrest (ASW Group) continued work on magnetic background noise measurement and analysis. Future emphasis will be on real-time processing and display of on-board measurements.

Professor Stephen Jauregui initiated a study of the electromagnetic compatibility of composite materials currently used in aircraft manufacture.

ACOUSTICS AND ELECTRO-OPTICS

Professor John Powers continued his work on computer-aided acoustical imaging. The main effort has been on data acquisition. A raster scanner and associated circuitry are functioning and further work on an interactive computer display is planned. Professor Powers also initiated a project to investigate techniques of optically excising various frequency components within an RF signal. Excision is performed in the transform domain of an acousto-optic signal processor.

COMMUNICATIONS

Professor Jeffrey Knorr initiated a communications system study to determine the propagation loss for several line-of-sight radio paths in the Pacific Northwest. Both multipath and fading effects will be considered.

An investigation to determine the effectiveness of communications channels by measuring noise and interference and modeling propagation paths and antenna patterns was initiated by Professors Stephen Jauregui, Jeffrey Knorr and Glen Myers.

Professor John Ohlson continued the SATCOM Signal Analyzer Program. Digital techniques have been developed and applied in hardware for high speed spectrum analysis, and receivers have been developed for flexible signal monitoring. A developmental model SATCOM signal analyzer has been

built.

Fiber optic communications for underwater applications were studied by Professor John Powers.

TOXIC VAPOR LEVEL DETECTION/RECORDING

Professor John Duffin continued a program to use infrared techniques to detect and record toxic vapor levels in various Naval Air Rework Facility (NARF) work areas. Calibrations for some 50 vapors were made and measurements were taken in various work areas at NARF-North Island. Attempts were made to correlate and model vapor level versus production rate.

ESTIMATION AND CONTROL SYSTEMS

Professors Alex Gerba, George Thaler and Donald Layton (Aero) continued their project on analysis and design of the control systems for the Captured Air Bubble type surface effect ship. Development by experimental and analytical methods of models for surface effect ships was continued. Control system design and evaluation used these models.

SIGNAL PROCESSING

Professors Stephen Jauregui and Jeffrey Knorr continued a program on computer simulation of the Bulldog/Bullseye wideband system in an effort to test various proposed Bulldog improvements to the Bullseye HFDF system. Professor Jauregui also initiated a project to investigate intermodulation products and proper ways to specify them in wideband HF multicouplers.

Professor Sydney Parker initiated a project for zero-pole modeling of a signal or process, a technique allowing the identification of both numerator and denominator polynomial parameters.

Professor Sydney Parker also continued a program for discrete signal processing and digital filtering. The objectives are signal processing for voice track simulation and adaptive recursive digital filters for

image processing.

Professor George Sackman undertook a review of USSR literature to obtain a general idea of the status of signal processing in that country. Four areas of interest are maximum entropy spectrum analysis, adaptive filters, wave-periods statistics and fast Fourier transforms (FFT) analysis.

Professor Titus initiated a program for IR/EO image processing for missile tracking.

Professor Tien Tao continued a program whose objective is to detect point targets in images of low target-to-clutter ratios. This involves real-time focal plane processing also known as the area of "smart sensors" or "focal plane processing". Statistical focal plane processing approaches are being developed.

RANGE STUDIES

Professor Donald Stentz continued a project on acoustic arrays and adaptive processing of acoustic signals. Objectives are range enhancement obtained through the use of modern sensors and array technology and to study adaptive control systems.

Professors George Sackman and Donald Stentz continued a project on adaptive acoustic processing with applications to radiated noise measurements and shallow water ranging. In this same general area, Professors George Sackman and Bryan Wilson (Physics/Chemistry) continued their project of measurement of acoustic source levels using surveillance arrays and acoustic imaging techniques. The objectives are use of acoustic surveillance arrays for measurement of radiated noise source levels of submarines and to investigate the feasibility of using some of the recent developments in acoustic imaging technology and image data processing as improvements to existing systems now in use.

Professor Milton Wilcox finished the U.S. Army CDEC project involving

ranging location of objects moving in real-time in a potential ground encounter area (RMS system). A final report on improvements of system reliability was prepared.

SOLID STATE DEVICES

Professor Tien Tao continues to direct a research program concerning application of large scale integration (LSI) devices and their signal processing applications. Also involved are charge coupled devices (CCD) and charge transfer devices (CTD).

WAVE PROPAGATION

Professor Stephen Jauregui initiated a project to investigate the horizontal-vertical polarization effects on HFDF small aperture antennas. The objective is to develop skywave discrimination techniques for small aperture HFDF.

COMPUTERS-DISPLAY/GRAPHICS

Professor Mitchell Cotton initiated a project on computer algorithms and displays to create machine independent software tools for management of graphics resources in a large multi-computer network.

Title: Computer Algorithms and Display

Investigators: M. L. Cotton, Associate Professor of Electrical Engineering and Homer J. Rood, Sr., LT, United States Navy

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, Washington

Objective: To create machine independent software tools for management of graphics resources in a large multi-computer network.

Summary: A study was made of the mathematics and currently available algorithms for display of 3-dimensional images in motion. Representation of the images was planar polygonal mosaic. Viewing presentations included basic wire frame with hidden lines removed, and solid polygonal surfaces with hidden surface removal, shading and color. Characteristics of existing video graphic display hardware were then considered, including direct view storage tubes, vector generator CRT's, raster scan CRT's, and plasma panels. Based on the foregoing considerations, data structures were selected and a FORTRAN-based software package developed. To test the machine independent concepts a variety of graphical presentations were obtained using four different host computers (IBM 360/67, XDS 9300, Adage DPR-2, and PDP-11) and four different display devices (Ramtek raster-scan color CRT, Versatec electrostatic plotter, Tektronix storage-tube CRT, and Adage AGT/10 vector generator CRT). A technical report on the above work is in preparation.

Thesis Directed: H. J. Rood, Sr., "A Portable Three-Dimensional Graphics Software Package", Master's Thesis, September 1978.

Title: Investigation of Toxic (Known or Potential) Airborne Vapor Concentrations in Various Work Areas of the Naval Air Rework Facility, North Island

Investigator: J. H. Duffin, Professor of Electrical/Chemical Engineering

Sponsor: Naval Air Logistics Facility (NALF), Patuxent River, MD, Mr. Al Jones, via the Aircraft Environmental Support Office (AESO), North Island, Calif., Code 64270, Mr. Robert Hammond.

Objective: To calibrate a Wilks Foxboro portable infrared vapor analyzer (the Miran IA) for known or potentially toxic substances put into the air during daily work carried out at a Naval Air Rework Facility.

Summary: Following successful calibration for a given material, the Miran IA was stationed at various locations in a given work area for continuous, long-period monitoring of airborne vapor concentrations.

The Miran IA was calibrated for some 50 odd materials of a more-or-less toxic nature. These materials are known to be used in the daily work done at a rework facility. All data needed for plant investigation of vapor concentrations in work areas is now available.

Publications: A report is in preparation.

Title: Correlation of Work Area Vapor Concentrations with Production Rates

Investigator: J. H. Duffin, Professor of Electrical/Chemical Engineering

Sponsor: Naval Air Logistics Facility (NALF), Patuxent River, MD, Mr. Al Jones, via the Aircraft Environmental Support Office (AESO), North Island, CA, Code 64270, Mr. Robert Hammond.

Objective: To study hazardous gas concentrations in various work areas of the Naval Air Rework Facility, North Island to try to model the expected concentration versus productivity for a given work area.

Summary: Calibration work started during a research quarter at NPS was continued during an intersessional quarter at North Island. The infrared instrument (Miran IA) was updated by installing new silver bromide cell windows and by installing a new detector/preamplifier.

The Miran IA was used in painting and chemical ships to study concentrations of various vapors. In the time available, it was not possible to arrive at what constitutes "productivity" in these areas and so no modelling was done. Monitoring of vapor concentrations in these areas was done.

Publications: A report is in preparation in combination with the work done during research quarter in residence at NPS.

Title: Applications of Charge Transfer Devices

Investigator: T. F. Tao, Professor of Electrical Engineering

Sponsor: Naval Electronic Systems Command

Objective: To investigate and develop signal processing applications of Charge Transfer Devices.

Summary: Research carried out in this project was concentrated in the area of image processing applications of charge transfer devices during this period. Specifically, the purpose of image processing is to suppress background clutter and to enhance targets in infrared images. These problems became important due to the recent developments of infrared mosaic detector arrays and their potential applications in surveillance, search and track and weapon guidance. The specific objectives are two-fold. First, CCD (charge coupled device) tapped delay line devices are developed as nonadaptive and adaptive nonrecursive filters. Second, nonrecursive spatial filters are implemented by combining the CCD nonrecursive filter and the X-Y addressing read-out capability of the CID (charge injection device) camera. The spatial filters are designed by a statistical image estimation procedure based on the minimization of mean square error criteria. The theoretical algorithms will be implemented by a hardware setup consisting of a General Electric 100X100 CID camera, a Reticon TAD32 tapped delay line, digital control circuits, double correlated sampling read out circuits, 10 bit A to D converter and a DEC LSI-11 microcomputer as a controller. In addition to the control function, the LSI-11 also performs the thresholding and post thresholding operations needed in the image processing program for detection applications.

Publications: T. F. Tao, D. BarYehoshua, J. Adkins, B. Evenor and J. Jenkins, "Statistical Nonrecursive Spatial Filter for Clutter Suppression, Target Enhancement and Detection," Proceedings Sixth DARPA Strategic Space Symposium, pp. 28-1 thru 13 (1978).

T. F. Tao, "Real Time Signal Processing - Seminar Introduction," Proceedings 22nd SPIE Symposium, Vol. 154, pp. 2-6 (1978).

Thesis Directed: D. Baryehoshua "Two Dimensional Nonrecursive Filter for Estimation and Detection of Targets," (June 1977).

J. Adkins "Real Time Image Processor Using CTD Devices and Microcomputer," (September 1977).

J. Jenkins "Image Simulation and Display for Real Time Image Processing," (December 1977).

Title: VLSI Technology

Investigator: T.F. Tao, Professor of Electrical Engineering

Sponsor: Naval Ocean System Center

Objective: To support Naval Ocean System Center in their VLSI (Very Large Scale Integration) project.

Summary: Naval Ocean System Center has a three year "VLSI Technology" project from FY 77 through FY 79. The overall objective is to develop optimum applications of industrial mainstream VLSI technology in current and future Navy systems and to advance the development of VLSI devices in industry and make available devices which will provide a VLSI design option for specific Navy systems. This project at Naval Postgraduate School is to support NOSC in their VLSI technology program in the form of making survey of VLSI technologies and provide assessment of their contributions to selected defense applications. Three tasks have been carried out.

1. Survey of four families of VLSI technologies: one bipolar injection logic family and three short channel MOS logic families--DMOS, VMOS and CMOS/SOS. This task was assisted by students taking the Integrated Electronics course. The results have been presented in a paper "Progress of Bipolar Injection Logic and Short Channel DMOS and VMOS Logic" at the Symposium on "Future Applications of Large Scale Integrated Circuits in Military Systems" sponsored jointly by the Defense Department Research and Engineering Office and the Institute of Defense Analysis in Arlington, Virginia on August 9-11, 1977.
2. Assessment of the computational capabilities of six microcomputers for signal processing applications. The microcomputers studied are two 8 bits microcomputers--Intel 8048 and Zilog Z-80, and four 16 bits microcomputers--Texas Instruments 9900, Digital Equipment Corporation LSI-11, RCA ATMAC and Applied Technology ATAC. The results have been presented in an invited paper on "Applications of Microprocessors in Control Problems" presented at the 1977 Joint Automatic Control Conference held in San Francisco on June 22-24, 1977.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM.(U)

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3. Survey of fault tolerant computing and their impact to VLSI developments. NOSC has a fault-tolerant computing program at the Jet Propulsion Laboratory sponsored by their VLSI Technology project. They are also interested in a new approach to fault tolerance proposed by the Actron Division of McDonnell-Douglas Corporation under the name AWSI (Adaptive Wafer Scale Integration). A survey of fault tolerance approaches to digital computers was made with special attention given to their impacts to the development of VLSI technologies and the contribution of AWSI. This task was assisted by Lt. G. Deacon. A technical report is in preparation.

Publications:

T. F. Tao, "Progress of Bipolar Injection Logic and Short Channel DMOS and VMOS Logic," Proceedings of the Symposium on Future Applications of Large Scale Integrated Circuits in Military Systems", pp III-119-142 (1977).

T. F. Tao, D. BarYehoshua and R. Martinez, "Applications of Microprocessors in Control Problems," Proceedings of Joint Automatic Control Conference, pp. 8-16 (1977).

Student Participation:

Supporting works to NOSC under this project are not directly the thesis studies but are related to either term projects or thesis of the following students:

D. BarYehoshua, J. Adkins, E. Cummins, G. Deacon

Title: Analysis and Design of the Control Systems for the C.A.B. Type Surface Effect Ship

Investigators: Alex Gerba, Jr., Associate Professor of Electrical Engineering, George J. Thaler, Professor of Electrical Engineering and Donald M. Layton, Associate Professor of Aeronautics

Objective: Continued development by experimental and analytical methods of models for the Surface Effect Ships that can be used for design of control systems. Design and evaluation of control systems using these models.

Summary: The summary of experimental activities on this research can be found in Professor Layton's report. The analytical work for this FY resulted in 2 reports: one on the procedure for scaling up touring tank data and the other on the important air flow characteristics and how they affect (ride) motion in the vertical plane. After over 6 years of part-time research, the project office has requested that we take a more active part in the current design evaluations for the proposed 3000 ton Surface Effect Ship. In addition to analytical design, our efforts will include Hybrid Simulation (man-in-the-loop) which has not been performed to date and will be necessary for proper evaluation of the designs.

Publications: A. Gerba, Jr., and G. J. Thaler, "A Method for Scaling the Heave Motion Equations of the C.A.B. 6-D.O.F. Loads and Motion Program from Model to Full-Size Craft", Technical Report NPS-62-77-002, December 1977.

A. Gerba, Jr., and G. J. Thaler, "Sensitivity Analysis of the XR-3 Heave Equations to Changes in Plenum Air Leakage and Influx Rates", Project Report NPS-62-78-008PR, September 1978.

Title: A Study of the Effect of Click Jammers on U. S. Navy Radar Systems

Investigators: David B. Hoisington, Professor of Electrical Engineering and Jeffrey B. Knorr, Associate Professor of Electrical Engineering

Sponsor: Naval Intelligence Support Center

Objective: To investigate the ability of shipboard radars to detect key targets in the presence of Soviet jamming.

Summary: The purpose of this investigation is to determine the degradation in performance to be expected for certain shipboard radars in the presence of jamming by Soviet click jammers. The steps taken this year include an initial effort to determine the quality of the noise generated by this jammer series, and investigation of burn-through ranges in a situation where a click jammer is used in a stand-off mode.

Title: An Investigation of Intermodulation Products and Proper Ways to Specify Them in Wide Band HF Multicouplers

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Security Group

Objective: To examine current solid state wide band HF multicouplers in use at communications sites, determine their weaknesses and recommend changes in specifications to eliminate these weaknesses.

Summary: Three different classes of multicouplers have been examined. The narrow band specifications which were applied to these wide band systems were totally inadequate. New techniques for specifying the system using a combination of wide band noise and discrete signals are being developed.

Publications: Letter reports have been sent to the sponsor.

Title: Electromagnetic Compatibility of Composite Materials

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Air Systems Command, 3022E

Objective: New data bases are being developed by NAVAIR on electromagnetic and environmental problems in operation of aircraft built of composite material. NPS is assisting them in getting a reliable data base for use in design requirements.

Summary: NPS has developed new probes for measuring fields within composite structures and is doing some flight test data analysis on static developed by composite structure.

Publications: Letter reports have been sent to the sponsor.

Title: An Investigation of Task Force Information and Timeliness Requirements for Tactical Over-the-Horizon Missile Launching

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: National Security Agency, Fort Meade, Maryland

Objective: To determine quantity and quality of intra-task force and shore support including timeliness for launching of over-the-horizon missiles.

Summary: Classified literature on weapons, sensors and communications have been reviewed pertaining to the launching of over-the-horizon weapons. This information was combined into a scenario for timeliness, accuracy, and target identification requirements.

Title: Computer Simulation of the Bulldog/
Bullseye Wide Band System

Investigator: S. Jauregui, Associate Professor of
Electrical Engineering

Sponsor: Naval Electronics Systems Command,
PME-107

Objective: To test various proposed Bulldog im-
provements to the Bullseye HFDF sys-
tem to see which were operationally
the best buy for throughput.

Summary: The wide band bulldog improvements
which have recently been installed at
Winter Harbor, Maine were simulated at
NPS to select which improvements were
to be made and, secondly, what kind
of results should be expected in
various operational situations.

Title: Modulation, Propagation and Noise Studies

Investigators: S. Jauregui, G. Myers and J. Knorr, Associate Professors of Electrical Engineering

Sponsor: Naval Electronics Systems Command, PME-117

Objective: To determine effectiveness of communications channels by measuring noise, interference, and modeling propagation paths and antenna patterns.

Summary: (October 1977 - January 1979) Noise and interference collected at 12 worldwide sites and categorized. Simulations run on propagation paths utilizing computer modeling of wide aperture antennas.

Title: Investigation of Horizontal-Vertical Polarization Effects on HFDF Small Aperture Antennas

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Electronic Systems Command, PME-107

Objective: To develop skywave discrimination techniques for small aperture HFDF.

Summary: Data collected from the AN/BRD-7 dipoles and loops is being investigated to determine possible discriminants for skywave propagation. Several possible discriminants have been investigated. This program is continuing using cross loop antenna data collected at Southwest Research Institute. An antenna similar to the narrow aperture HF antenna was used on the prototype Outboard System.

Thesis Directed: G. S. Edwards, "Investigation of High Frequency Skywave Discrimination Using a Small Aperture Antenna", Electrical Engineer's Degree Thesis, March 1978, also published as a Technical Report NPS-62-78-006, March 1978.

Title: Communications System Studies

Investigator: Jeffrey B. Knorr, Associate Professor
of Electrical Engineering

Sponsor: Naval Undersea Weapons Engineering
Station, Keyport, Washington.
Code 801 3A, R. Rabel.

Objective: To determine the propagation loss
for several line-of-sight radio
paths in the Pacific Northwest,
including the effects of multi-
path and fading.

Summary: A propagation data acquisition
system is under development.
It is expected that this effort
will be completed during FY 79
and that the system will be in-
stalled.

Publications: J. B. Knorr, "A Radiowave Propa-
gation Data Acquisition System,"
NPS technical report in preparation.

Theses Directed: Two related theses are in progress.

Title Naval Electronics Systems Command Research Chair in Electrical Engineering

Investigator: Basil R. Myers, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: The primary objective of this visiting research chair professorship is to foster research at NPS which is of particular interest to the Naval Electronics Systems Command. A secondary objective is to perform research liaison among NPS, NAVELEX Navy Laboratories and industry.

Summary: The research of Professor Myers was in the area of graph theory with applications to telecommunications networks.

Conference Presentations:

B. R. Myers, "Communication networks with optimal connectivity", Graduate Seminar, EE Dept., University of Santa Clara, Santa Clara, CA, January 23, 1978.

B. R. Myers, "Optimally-connected telecommunications networks", EE Seminar Series, Naval Postgraduate School, Monterey, CA, February 9, 1978.

B. R. Myers, "Graph theory and telecommunications networks", The Information Linkage between Applied Mathematics and Industry Workshop, Naval Postgraduate School, Monterey, CA, February 25, 1978.

B. R. Myers, "Challenges and responsibilities facing the university", General Education Seminar, California State Univ., Long Beach, CA, May 5, 1978.

B. R. Myers, Panelist, IEEE U. S. Activities Board Professional Activities Workshop, Los Angeles, CA, September 10-11, 1978.

Publications: B. R. Myers, "Graph theory and telecommunications networks". Abstracts, The Information Linkage between Applied Mathematics and Industry Workshop, Naval Postgraduate School, Monterey, CA, p. 49 (Feb 1978).

B. R. Myers, "Guest Editorial: On the philosophy of engineering education. IEEE Trans. on Education, vol. E-21, no. 1, pp. 1-2 (Feb 1978).

B. R. Myers, "Enumeration of tours in Hamiltonian rectangular lettice graphs, accepted for publication in Mathematics Magazine, Math. Assoc. of America.

B. R. Myers, "Planar reflex isomorphs of Terakado's mirror-antisymmetrical constant resistance networks", accepted for publication in IEEE Trans. on Circuits and Systems.

B. R. Myers, "Graph theory and the telecommunications network". To be presented at the IEEE International Symposium on Circuits and Systems, Tokyo, Japan, July 17-19, 1979.

B. R. Myers, "The Klee and Quaife minimum (d,1,3)-graphs revisited". To be presented at the IEEE International Symposium on Circuits and Systems, Tokyo, Japan, July 17-19, 1979; also submitted for publication in SIAM Review.

B. R. Myers, "Revamping the non-technical part of the curriculum". To appear in IEEE Trans. on Education, Special Issue on Curriculum Development in an Era of Rapid Change, May 1979.

B. R. Myers, Critique of four of his papers on secondary- and tertiary-level education in mathematics and in engineering in the U.S. for "Collected Works of Norbert Wiener", MIT Press, Cambridge, Mass. (scheduled to appear in 1981).

B. R. Myers, C. A. Desoer, J. F. Kaiser, and W. G. Howard, "Position paper on engineering registration". IEEE Circuits and Systems, vol. 12, no. 4, pp. 20-21 (August 1978).

B. R. Myers, "Digital filters with a Fibonacci-based impulse response", undergoing first revision for publication in IEEE Trans. on Circuits and Systems (Letters); also accepted for presentation at 12th Annual Asilomar Conf. on Circuits, Systems and Computers, Pacific Grove, CA, Nov 6-8, 1979.

Title: SATCOM Signal Analyzer

Investigator: J. E. Ohlson, Associate Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command, PME-106-1, W. R. Coffman

Objective: Develop techniques and hardware for monitoring of UHF SATCOM signals.

Summary: Digital techniques have been developed and applied in hardware for high speed spectrum analysis. Receivers have been developed for flexible signals monitoring. A developmental model SATCOM Signal Analyzer has been built. Ongoing work includes construction of a prototype system for use by the Navy.

Theses Directed:

Z. D. Zuber, Jr., "Hardware Development for a Satellite Signal Analyzer", Master's Thesis, December 1978.

M. J. Langston, "Data Acquisition Unit for SATCOM Signal Analyzer", Master's Thesis, June 1978.

B. G. Edgington, "Systems Development for Satellite Oscillator Stability Measurements", Master's Thesis, June 1978.

W. A. Rhoades, "Integration of the Primary Receiver into the NAVPGSCOL SATCOM Signal Analyzer", Master's Thesis, June 1978.

R. R. Mead, "Digital Control and Interfacing for a High Speed Satellite Communications Signal Processor", Master's Thesis, September 1978.

T. T. W. Bruner, "Software Development for a Satellite Signal Analyzer", Master's Thesis, September 1978.

R. M. Thomas, "Implementation of Control Bus Hardware and Utilization of the Naval Postgraduate School Satellite Signal Analyzer", Master's Thesis, September 1978.

Title: Discrete Signal Processing and Digital Filtering

Investigator: Sydney R. Parker, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: To continue research in the areas of signal processing for voice track simulation and adaptive recursive digital filters for image processing.

Summary: Hidden limit cycle oscillations in the wave digital filter have been discovered. The oscillations have not been detected heretofore because they do not ordinarily appear in the filter output. It has also been demonstrated that under certain input conditions these oscillations can be made to appear in the filter output. The result is significant because these limit cycles introduce correlated noise errors and occupy storage register capacity.

An adaptive recursive digital filter has been developed in which feed forward and feedback gains are adjusted adaptively to minimize a least squares performance index on a sliding window basis. A two-dimensional version of the adaptive filter is developed and its performance has been compared with the optimal Weiner filter. Experimental results show that the adaptive filter is effective in separating a three-diagonal streak trajectory from a background of correlated noise (clouds) and white noise.

Publications: S. R. Parker and Soon-Ju Ko, "A Two-Dimensional Adaptive Recursive Digital Filter in Image Processing", Proceedings of the IEEE International Symposium on Circuits and Systems, IEEE #78CH138-ICAS, May 1978, pp 308-312.

S. R. Park and F. A. Perry, "Hidden Limit Cycles in Wave Digital Filters", submitted to IEEE Transactions on Circuits and Systems.

Theses Directed:

Soon-Ju Ko, "An Adaptive Recursive Filter", Engineer's Degree Thesis, December 1977.

Bjarne Rostad, "A Comparative Study of the Wave Digital Filter", Master's Thesis, December 1977.

Title: Reduced Order Models for Simulation

Investigator: Sydney R. Parker, Professor of
Electrical Engineering

Sponsor: Naval Ocean Systems Center

Objective: The simulation of complicated large scale analog and digital models is approaching the limits of large general purpose digital computers. This area of simulation has been addressed by the use of simpler and equally effective models. However, the use of simpler models is not always a valid representation of the actual model and some means of adaptation must be provided for a model to assure its usefulness. This project will continue to explore the use of self-adaptive models.

Summary: A technique for zero-pole modeling of a signal or process has been developed. This technique allows the identification of both numerator and denominator polynomials parameters. The approach is a combination of linear prediction and moving average estimation. The order of the numerator and denominator polynomials is assumed apriori.

Publications: S. R. Parker, "Modeling for Fault Tolerance", Proceedings of the National Security Industrial Association, Industry Joint Services Automatic Test Conference, April 1978, pp 82-83.

Thesis Directed: J. Martinos, "Macroscopic Modeling of Systems and Processes", Ph.D. proposal, March 1978.

Title: Techniques of RF Signal Analysis

Investigator: John P. Powers, Associate Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command, Code 350

Objective: This is a new research program to investigate techniques of optically excising various frequency components within an RF signal. The excision is performed in the transform domain of an acousto-optic signal processor.

Summary: This investigation is in its initial stages. Initial acquisition and testing of the various systems components is proceeding. A CCD linear imaging array and a self scanned photodiode array are operating and their characteristics are being compared. A first order computer model of the system is being developed and investigation into the literature of various optical excising devices is proceeding.

Title: Computer Aided Acoustical Imaging

Investigator: John P. Powers, Associate Professor of
Electrical Engineering

Sponsor: National Science Foundation
Division of Engineering
Automation, Bioengineering and Sensing
Systems Program
Mr. Norman Caplan

Objective: This project investigates the verification of the use of a computer to produce images from complex valued scales diffraction patterns produced from reflected or transmitted ultrasound. A coherent detector is scanned through the diffraction pattern and the amplitude and phase are recorded. A computer performs the image formation and image processing.

Summary: Efforts to date have concentrated on the data acquisition portions of the project. A mechanical scanner has been purchased and circuitry designed and tested to precisely and reproducibly scan a raster pattern with precision timing marks being generated every half wavelength (.75mm). Counting circuitry controls the raster size. Plans are in progress to completely automate the raster scan system. Circuitry has been designed to filter, amplify, and synchronously detect the amplitude and phase of the received signal. The amplitude information is logarithmically compressed to retain the full dynamic range. The phase information is detected through an IC phase detector. The signals are then digitized in two A-D convertors and will be recorded on a digital cassette recorder. The recording circuitry and the reading circuits are currently under design for compatible formatting to read the data into the computer memory. Further work on the interactive computer display is also planned for the near future.

Publications: J. P. Powers, J. R. Y. DeBlois, R. T. O'Bryon and J. W. Patton, Acoustical Holography, Vol. 8. Chapter titled "A Computer Aided Ultrasonic Imaging System". Accepted for publication.

**Conference
Presentations:**

J. P. Powers, R. T. O'Bryon and J. W. Patton, "An Ultrasonic Imaging System Incorporating Computer Aided Coherent Processing". Presented at the 94th Meeting of the Acoustical Society of America, Miami Beach, Florida, 12-16 December 1977. Abstract published in J. Acoust. Soc. Am., Vol. 62, Suppl. No.1, p. 522, Fall 1977.

J. P. Powers, J. R. Y. DeBlois, R. T. O'Bryon and J. W. Patton, "A Computer Aided Ultrasonic Imaging System". Presented at the 8th International Symposium on Acoustical Imaging, Key Biscayne, Florida, 29 May - 2 June 1978. Full paper will be published in Acoustical Holography, Vol. 8.

Thesis Directed:

Capt J. R. Y. DeBlois, "An Improved Hardware Design for a Computer Aided Acoustic Imaging System," Master's Thesis, December 1977.

Lt James C. Culpepper, "Analog to Digital Conversion and Hardware Improvement for a Computer Aided Acoustic Imaging System," Master's Thesis, September 1978.

- Title:** Acoustic Arrays and Adaptive Processing of Acoustic Signals
- Investigator:** Donald A. Stentz, Associate Professor of Electrical Engineering
- Sponsor:** Research and Engineering Department
Naval Undersea Warfare Engineering Station, Keyport, Washington 98345
- Objectives:**
- a. To study the range enhancement obtained through the use of modern sensors and array technology.
 - b. To study adaptive control systems and to determine whether or not new technology can be used effectively on the acoustic test and exercise range.

Summary:

During the research year an active DIMUS (Digital Multibeam Steering) system was given to NPS by the Naval Sea Systems Command. Some time was spent in determining how the system works, and to determine how it might be used to enhance course and thesis effort in acoustic systems. The second objective was to use the adaptive system in the context of an acoustic test range environment. Before this can be done however a test signal simulator must be designed and built. There is now a thesis student who is building a signal simulator on a small scale (16 signal sources). If he is successful, then a large scale simulator can be built that will supply the necessary signal sources for the DIMUS system.

A final version of the survey of adaptive control systems was completed and distributed. This survey contains an extensive bibliography useful to those working in adaptive control systems.

Through a visit by LCDR Petersen (NUWES Detachment, San Diego), 16 graduate students became interested in studying the Sonar Accuracy Check (SAC) site at Long Beach to determine how this site might be changed, or how future SAC sites might be constructed so that they are more accurate, require less time to perform their tasks, serve a larger variety of platforms, and test systems not compatible with the present SAC site environment. These students divided the study into the following categories:

- a. Physical considerations of SAC sites
- b. Measurements and calibration
- c. Data collection and data processing
- d. Weapons systems measurements

Each group sent a representative to the SAC site at Long Beach for the purpose of interviewing the management and operating personnel. As a result of their study, and the data they collected from many sources, they wrote a report summarizing their findings. This report is being studied in an effort to find fruitful thesis topics. One of the goals of this effort is to eventually be able to define the desirable characteristics that future SAC sites must possess in order to properly do their job. The research effort over the next year will be directed toward this goal.

Publications:

D. A. Stentz, "A Brief Survey of Adaptive Control Systems", Technical Report, NPS-62-78-003, March 1978.

Title: Sampled Analog Signal Processing

Investigator: T. F. Tao, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop theory, design procedure and applications of sampled analog recursive and nonrecursive filters using charge transfer devices (CTD).

To investigate the limitations and sensitivities of sampled analog signal processing.

Summary: This is a continuing project from FY 77. However, of the two studies carried out last year, the study of sampled analog recursive comb filters was completed and not continued this year. The other project on the study of sampled analog discrete Fourier transforms was continued during FY 78. In addition, a new project was started in the study of sampled analog nonrecursive spatial filters. Their progress will be summarized in the following.

(1) Sampled Analog Discrete Fourier Transforms:

Two sampled analog discrete Fourier transform algorithms were compared with the digital Fast Fourier Transform algorithm last year by determining the output noises of these three discrete Fourier transform algorithms resulted from their respective sources of inaccuracies. It was found that the effects of charge transfer inefficiencies are very different in the two sampled analog DFT algorithms--Chirp Z transform and Prime Z transform. A more detailed simulation study was carried out during this year. (A part of Magos' Engineer Thesis.)

(2) Sampled Analog Nonrecursive Spatial Filters:

The applications of sampled analog nonrecursive filters using CTD tapped delay

lines or CTD analog correlators for image processing are studied. In another sponsored project, statistical spatial filters were developed for suppression of background clutter in surveillance systems using new infrared mosaic detector arrays. It was found that spatial filters of sizes smaller than 5×5 are effective in suppressing infrared clutter if the targets are far enough away from the sensor system and appear as point targets and line targets. Short CCD tapped delay lines and CCD analog correlators are attractive candidates for the implementation of these spatial filters. This project is to demonstrate the feasibility of this application. A Reticon 32 bits TAD32 tapped delayed line was selected to implement the spatial filter of sizes up to 5×5 . It is a part of a larger system consisting of a DEC-LSI-11 16 bits microcomputer, a GE CID camera of 100×100 pixels and associated electronics for scanning the camera, nondestructively reading out from the camera, analog to digital conversion of the data after the CTD spatial filter and other interfacing functions. (Theses of Adkins and Magos)

In anticipation that sampled analog devices may not have adequate accuracy for the clutter suppression requirements and also is not programmable, an effort was started to investigate the use of analog correlator as an adaptive filter. If it is feasible, the adaptive feature will remove both deficiencies of less accuracy and no programmability in typical sampled analog devices. It will be attractive because the processing speed is higher in a sampled analog device.

A preliminary study of the hardware implementation of adaptive filter was made. It will be extended to the investigation of new analog correlator when it becomes available in late 1978 or early 1979. (Panourgias' thesis)

- Publications:** T. F. Tao, D. BarYehoshua, J. Adkins, B. Evenor and J. Jenkins, "Statistical Nonrecursive Filter for Clutter Suppression, Target Enhancement and Detection", Proceedings of 6th DARPA Strategic Space Symposium, Stanford Research Institute, March 1978, pp 28-1 to 28-10.
- T. F. Tao, D. BarYehoshua, B. Evenor and J. Adkins, "Statistical Nonrecursive Spatial Filter for Processing of Infrared Mosaic Sensor Images", Proceedings of 22nd Annual Society of Photo-optical Instrumentation Engineers, Vol. 156, Modern Utilization of Infrared Technology IV, pp 10-19, 1978.
- Theses Directed:** J. D. Adkins, "Real Time Image Processor Using CTD Devices and Microcomputer", Master's Thesis, September 1977.
- T. I. Panourgias, "Preliminary Results and Applications of Adaptive Filters", Master's Thesis, December 1977.
- D. G. Magos, "Real Time Signal Processing Studies: Spectral Analysis Using Charge Transfer Devices and Microcomputer Support of a Hardware Spatial Filter", Electrical Engineer's Thesis, March 1978.

Title: Torpedo Tracking Studies

Investigator: Harold Titus

Sponsor: NUWES
Keyport, Wash 98345
J. Veatch, Code 70

Objective: We will provide real time torpedo tracking for Keyport from their time pulses. Time of arrivals at the 4 bottom mounted hydrophones in an array are taken as observation in an Extended Kalman Filter. Estimates of torpedo position and velocity result.

Summary: A Kalman Filter to accomplish this is being developed.

Title: EA-6B Mission Planning

Investigator: Harold Titus, Professor of Electrical Engineering

Sponsor: Naval Air Test Center
Patuxent River, ME 20670

Objective: Mission Planning

Summary: An EA-6B Mission Planning program was put on three a/c carriers for evaluation. This was the fourth program in this area and the first to go to sea. The AF paid Litton 3 million for a mission planning program that was never used.

Theses Directed: Beaudet, Carl Allen
"EA-6B Mission Planning Program"
Master's Thesis, December 1977.

O'dell, Paul
"EA-6B Mission planning and route optimization program"
Master's Thesis, September 1978.

Watts, Ken
"Electronic Warfare support jamming pre-mission route optimization"
Master's Thesis, December 1977.

Smith, Stephen W.
"Operational EA-6B Mission Planning Program"
Master's Thesis, March 1979.

Title: Evaluation, Simulation and Analysis for the Crossbow Committee

Investigator: Harold A. Titus, Professor of Electrical Engineering

Sponsor: Army Missile R&D Command
Redstone Arsenal, AL

Objective: To provide consultation to the missile intelligence committee, including simulations.

Summary: The missile simulations at Eglin, AFB, were analyzed and compared with some developed at NPS. The SA-6 was evaluated against an ECM environment.

A hardware study was conducted on angle gate steal against a conical scan radar.

Theses Directed: Framme, Danny
"A cooperative blank jamming simulation against a semi-active missile system"
Master's Thesis, September 1978.

Capute, Joseph
"Jamming effectiveness of a conical scan trackbreak modulation utilizing gaussian noise"
Master's Thesis, December 1978.

DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology has continued along several main lines: (1) Numerical weather and ocean modeling and prediction, (2) Analysis and dynamics of tropical weather systems, (3) Marine boundary-layer turbulence, (4) Marine fog observation, analysis and prediction, and (5) Polar studies. Under each of these headings, a number of related investigations are being pursued by various faculty members.

NUMERICAL PREDICTION

Under this heading are included: modeling the analysis and prediction of large-scale weather systems by G. J. Haltiner and R. T. Williams; numerical prediction of hurricanes by R. L. Elsberry; ocean mixed layer modeling by R. L. Elsberry; and boundary-layer parameterization by K. L. Davidson.

With regard to Elsberry's projects, he and his students continue to cooperate in the Navy effort to develop an operational tropical cyclone prediction model.

Evaluation of the Penn State mesoscale model with operational tropical cyclone data is being carried out in conjunction with the Naval Environmental Prediction Research Facility. Work is also in progress to evaluate the systematic errors of the operational model and to derive statistical regression equations to reduce these errors.

One-dimensional, oceanic mixed layer models are being used by R. L. Elsberry and R. W. Garwood (Oceanography) to predict the upper oceanic thermal response to atmospheric forcing. The objective is to simulate the response on diurnal, synoptic and seasonal time scales. The feasibility of using this type of model for real-time prediction of ocean thermal structure is also being tested. A joint effort with R. L. Haney has been started to couple the mixed layer model with an oceanic circulation model.

NAVAIR Research Chair incumbent R. A. Anthes adopted and further developed a regional fine-scale multilevel numerical prediction model for application to the eastern U.S. and the Mediterranean area. This model showed considerable skill in forecasting cyclogenesis over the area of concern.

ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C. P. Chang, R. L. Elsberry and R. T. Williams are investigating various aspects of the dynamics of tropical weather systems, including development of hurricanes and typhoons by

Elsberry, the dynamics and energetics of tropical synoptic and planetary scale waves by Chang and Williams, and the diagnostic analysis of winter and summer monsoon circulations by Chang.

C. P. Chang and K. M. Lau are using domain-averaged climatic numerical models to investigate the various mechanisms pertinent to the large-scale interaction between tropical atmosphere and oceans.

Among the phenomena being studied are the Walker circulation, the Hadley circulation and the El Niño fluctuations.

MARINE BOUNDARY LAYER TURBULENCE AND AEROSOLS

Research in this area includes four interdisciplinary observational and theoretical projects for which K. L. Davidson is principal investigator. Objectives of the individual projects are to (1) obtain surface layer scaling laws for marine fog occurrences, (2) describe the height variation of optically relevant turbulence parameters in terms of stability and inversion characteristics, (3) obtain measurements of the EM index of refraction profiles within the surface layer (0 to 30 m), and (4) develop an approach to relate marine aerosol total concentrations and size distributions to boundary layer fluxes using existing surface layer scaling techniques. The primary results in this project will be relationships between small scale turbulence intensities or gradient measures and bulk parameters, such as wind speeds and air-water temperature and humidity differences.

MARINE FOG OBSERVATION, ANALYSIS AND PREDICTION

An interdisciplinary project, involving R. J. Renard and faculty members from the Department of Oceanography, is concerned with the observation, climatology analysis and numerical/statistical prediction of fog over open ocean and coastal regimes, both on a regional and hemispheric scale.

POLAR WEATHER STUDIES

Currently R. J. Renard's research is concerned with the observational network commensurate with synoptic/mesoscale weather events over the Antarctic area. In addition to data from conventional and satellite sources, data from prototype remote automatic weather stations and the Airborne Research Data-Handling System aboard an LC 130R Aircraft have been analyzed for their contributions both to the scientific and operational weather endeavors in support of the U. S. mission in Antarctica.

- Title:** Tropical Large-Scale Atmosphere-Ocean Coupling
- Investigators:** Chi-Pei Chang, Associate Professor and
K. M. William Lau, Adjunct Assistant
Professor of Meteorology
- Sponsor:** Foundation Research Program (6.1)
- Objective:** To study the large-scale atmosphere-ocean interaction especially with regard to short term (seasonal to interannual) climatic variations in the tropics. These include the possible effect of the sea-surface temperature on the local rainfall, and the variations and interactions of the Walker, Hadley and monsoon circulations.
- Summary:** Numerical experiments using domain-averaged models are carried out to study the response of a coupled atmosphere-ocean system to steady forcings, seasonal variations and large perturbations and continuous short-period random forcings. The results show that the sea-surface temperature is the primary factor in determining the location and transition of the tropical rainbelt. In addition, moisture convergence and static stability of the lower atmosphere also control the convective activity in the ITCZ. Further studies on the possible effects of sea-surface temperature and Walker circulation are planned.
- Conference Presentation:** K. M. W. Lau, "Tropical Large-Scale Atmosphere-Ocean Coupling", presented at the Spring Annual Meeting, American Geophysical Union, Miami, April 1978.
- Publications:** K. M. W. Lau, "A Numerical Study of Tropical Large Air-Sea Interaction", submitted to Journal of Atmospheric Sciences, 1978.

- Title:** Dynamics of Tropical Waves and Monsoons
- Investigators:** Chih-Pei Chang, Associate Professor of Meteorology, Roger T. Williams, Professor of Meteorology
- Sponsor:** National Science Foundation
- Objective:** To study the dynamics of large-scale flow in the tropics including stationary and propagating waves and monsoons, in terms of their development, maintenance and structure and the interactions between them. This is a continuing project, the recent emphases include the numerical modeling of the wave disturbances imbedded in the monsoons and the preparation for the international Monsoon Experiment (MONEX) of 1978-79.
- Summary:** Upper tropospheric waves during the summer monsoon are studied using a linear numerical model with both inflow-forcing, outflow-radiation boundary conditions and cyclic boundary conditions. Results show that the cyclic conditions lead to more irregular wave behavior as compared to the time periodic behavior which was found with inflow-forcing and outflow-radiation boundary conditions. When the wave structure was average, the two models gave very similar results. Existing conventional and satellite data are used for a pre-MONEX pilot study of the interaction between northeast cold surges and near-equatorial convection over the Winter MONEX area. The synoptic results suggest that the convective disturbances are intensified by enhanced low-level convergence due to the freshening of monsoon winds which occur prior to the equatorward penetration of surface cold air. The planetary scale results indicate a relationship between the cold surges and the variation of the Hadley and Walker circulations.
- Publications:** C.-P. Chang (with J. B. Tupaz and R. T. Williams), "A Numerical Study of the Locally Unstable Barotropic Easterly Jet", Indian Journal of Meteorology, Hydrology and Geophysics, 29, April 1978.

C.-P. Chang (with R. J. Pentimonti), "A Numerical Study of Time-Mean Northern Summer Monsoon with Steady and Fluctuating Heating", Indian Journal of Meteorology, Hydrology and Geophysics, 29, April 1978.

C.-P. Chang (with J. B. Tupaz and R. T. Williams), "A Numerical Study of Barotropic Instability in a Zonally Varying Easterly Jet", Journal of Atmospheric Sciences, 7, July 1978.

C.-P. Chang (with D. M. Delaney and E. Maas, Jr.), "Possible Influences of Sea-Surface Temperature on the Easterly Waves Over the Equatorial Pacific", Journal of Atmospheric Sciences, (decision pending).

C.-P. Chang, Reply to comments on "Viscous Internal Gravity Waves and Low-Frequency Oscillations in the Tropics", Journal of Atmospheric Sciences, 1978.

C.-P. Chang (with J. E. Erickson and K. W. Lau), "Northeasterly Cold Surges and Near-Equatorial Convective Disturbances Over the Winter MONEX Area During December 1974. Part I: Synoptic Aspects", Month Weather Review, (decision pending).

R. T. Williams (with C.-P. Chang), "Tropical Wave Dynamics", Project Report, NPS63Cj78031, March 1978.

Thesis Directed:

Bruce Nagle, "A Numerical Study of Barotropic Instability in a Zonally Varying Easterly Jet with Boundary Conditions", Master's Thesis, September 1978.

Title: Interannual and Spatial Variations of Sea-Surface Temperature, Tropical Waves and Mean Flows

Investigator: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: National Environmental Satellite Service
NOAA

Objective: To study the behavior and interrelationship between the interannual and spatial variations of sea-surface temperature, synoptic waves and planetary-scale circulations in the tropics using radiosonde and satellite data.

Summary: Composite studies of the structure of wave disturbance over the tropical Pacific during the July-December period of 1972-76 have been completed. The results indicate possible local effects of sea-surface temperature on the convective activity modulated by wave disturbances, and that the waves are probably generated by non-thermal energy sources in the east-central Pacific where the sea-surface temperature-influenced wave convective activity may determine the wave amplitude. A study in the interannual and within-season variations of the summer monsoon has begun. In this study the 200 mb wind and satellite data are used to diagnose the planetary-scale circulations during the summer monsoons of 1974-76. Very large differences in both the seasonal mean flow pattern and intraseasonal fluctuations are found. These results are being analyzed.

Publications: C.-P. Chang, (with D.M. Delaney and E. Maas, Jr), "Possible Influences of Sea-Surface Temperature on the Easterly Waves over the Equatorial Pacific," Journal of Atmospheric Sciences, (decision pending).

C.-P. Chang, (with J.E. Erickson and K.W. Lau), "Northeasterly Cold Surges and Near-Equatorial Convective Disturbances over the Winter MONEX Area During December 1974. Part I: Synoptic Aspects". Month Weather Review, (decision pending).

Theses Directed: Donald J. Beprestis, "Structure of Synoptic-Scale Waves in the Tropical Pacific During July-December 1974-1976", Master's Thesis, December 1977.

Vincent F. Looft, "A Study of the Variation of Convective Activity Associated with Easterly Waves in the Tropical Pacific Using Satellite Radiation Data", Master's Thesis, March 1978.

Title: Studies of Large-Scale Tropical Motions

Investigator: Chi-Pei Chang, Associate Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: To simulate planetary-scale monsoon circulations and the associated synoptic-scale disturbances in a numerical global model and to study the scale interactions.

Summary: Study of the planetary scale monsoon during northern summer using numerical modeling is continued. Results of long-term integrations of different heating periodicities are being analyzed with respect to the vorticity and energy budgets. Comparison between linear and nonlinear models are planned. This project is also supported in part by the National Science Foundation.

Publications: C.-P. Chang, (with J.B. Tupaz and R.T. Williams), "A Numerical Study of the Locally Unstable Barotropic Easterly Jet," Indian Journal of Meteorology, Hydrology and Geophysics, 29, April 1978.

C.-P. Chang, (with R.J. Pentimonti), "A Numerical Study of Time-Mean Northern Summer Monsoon with Steady and Fluctuating Heating," Indian Journal of Meteorology, Hydrology and Geophysics, 29, April 1978.

C.-P. Chang, (with J.B. Tupaz and R.T. Williams), "A Numerical Study of Barotropic Instability in a Zonally Varying Easterly Jet," Journal of Atmospheric Sciences, 7, July 1978.

Title: Fog Dynamics and San Nicolas Assessment

Investigators: K. L. Davidson, Associate Professor of Meteorology and G. E. Schacher, Associate Professor of Physics

Sponsor: Naval Air Systems Command, Air 370C

Objectives: Perform shipboard measurements and subsequent analysis to obtain scaling laws for numerical models which characterize marine fog formation, growth and maintenance. The purpose is to relate turbulent scale phenomena to bulk (mean) parameters and ultimately to synopsise descriptions. Secondly, to assess San Nicolas Island as to its representativeness of open ocean conditions.

Summary: A research cruise aboard the RV ACANIA was conducted in the vicinity of San Nicolas Island. The island was found to be representative of open ocean conditions as far as small scale thermal properties are concerned. We find that the meteorological station at the north tip of the island does suffer land influence, as evidenced by an acceleration of the mean flow, as the roughness changes at the land-sea boundary. Only a small amount of fog data was collected, due to conditions, and is being evaluated.

Publications: G. E. Schacher (with C. W. Fairall, K. L. Davidson and T. M. Houlihan), "Atmospheric Turbulence Measurements in Marine Fog During CEWCOM-76", Technical Report, NPS 61-77-004, December 1977.

G. E. Schacher (with C. W. Fairall, K. L. Davidson and T. M. Houlihan), "Atmospheric Marine Boundary Layer Measurements in the Vicinity of San Nicolas Island During CEWCOM-78", Technical Report, NPS 61-78-007, September 1978.

Title: Measurement of Evaporation Duct Height Over the Ocean

Investigators: K. L. Davidson, Associate Professor of Meteorology, T. M. Houlihan, Associate Professor of Mechanical Engineering and G. E. Schacher, Associate Professor of Physics

Sponsor: Oceanographer of the Navy

Objectives: Obtain accurate multi-level measurements of mean and turbulent wind, temperature and humidity to compute vertical profiles of refractive index. Determine the temporal variation of refractive index. Use an acoustic sounder to determine the top of surface based ducts and the boundaries of elevated ducts.

Summary: A research cruise aboard the USNS Kane in the Atlantic has been completed. This work was done in conjunction with related measurements (SECRET). Evaporation duct height was determined to vary from 1 to 25 meters, with a typical value of 16 meters. Bulk measurements can give a reasonable value of evaporation duct height (within a factor of two). Such measurements could be useful in predicting propagation characteristics.

Publications: G. E. Schacher (with C. W. Fairall, T. M. Houlihan and K. L. Davidson), "Evaporation Duct Height Measurements in the Mid Atlantic", Technical Report, NPS 61-78-005, August 1978.

Title: Interaction of the Oceanic Boundary Layer with Large-Scale Circulations

Investigators: R. L. Elsberry, Associate Professor of Meteorology, R. W. Garwood, Adjunct Professor of Oceanography and R. L. Haney, Associate Professor of Meteorology

Sponsor: Foundation Research Program (6.1)

Objective: To begin the systematic process of incorporating the one-dimensional turbulent mixed-layer processes into a large-scale ocean circulation model.

Summary: As a first step toward this objective, seventeen years of observations taken at ocean weather ship PAPA (50°N , 145°W) have been applied as surface boundary conditions for the Garwood (1977 J. Phys. Oceanogr.) mixed-layer model. The model simulations were performed to investigate the annual variability in the vertical temperature structure at PAPA, test the sensitivity of the model to increased vertical grid spacing, and determine whether or not this particular parameterization is practical for embedment in a general circulation model. The results of these simulations are encouraging as described in the conference presentation below. This project is being continued under sponsored research from ONR (code 481).

Conference Presentation: D. Adamec, R. L. Elsberry, R. L. Haney, and R. W. Garwood, "Developmental Experiments to Include Vertical Mixing Processes in Numerical Model Simulations of Ocean Anomalies", Fall Annual Meeting, AGU, San Francisco, California, 4-8 December 1978.

Title: Tropical Cyclone Studies

Investigator: Russell L. Elsberry, Associate Professor of Meteorology

Sponsor: Naval Air Systems Command (AIR-370)

Objective: Development of an operational numerical tropical cyclone prediction model for the North Pacific.

Summary: A cooperative effort to develop an operational numerical forecast model for tropical cyclones in the North Pacific was begun in 1975. Since that time a number of feasibility and data impact studies have been completed using numerical models developed at NPS and adapted by NEPRF and FNWC personnel. In the past year a method for adjusting the initial wind field to improve the Tropical Cyclone Model (TCM) track forecasts was described at the Eleventh Technical Conference on Hurricanes and Tropical Meteorology and was published in the Monthly Weather Review. This adjustment technique has been incorporated in the operational version of the model. A recent M.S. thesis by Walters (1978) evaluated the improvements in the TCM motion prediction resulting from an objective re-analysis to include DMSP wind direction estimates in the initial wind field. The new wind directions changed the analysis around the periphery of the storm but did not result in significant changes near the center of the storm. Consequently, there was very little improvement in the model forecasts that included the DMSP wind estimates versus the model results without the new data. Recent results from these data impact studies were presented at the Conference on Meteorology over the Tropical Oceans in London during August 1978.

Conference Presentations: J. D. Shewchuk and R. L. Elsberry, "Improvement of Short-Term Dynamical Tropical Cyclone Motion Prediction by Initial Field Adjustments", presented at Eleventh Technical Conference on Hurricanes and Tropical Meteorology, Miami Beach, American Meteorological Society, (1977), pp. 110-115.

R. L. Elsberry, J. D. Shewchuk and T. P. Walters, "Effects on Initial Data on a Dynamical Model of Tropical Cyclone Motion", presented at the Conference on Meteorology Over the Tropical Oceans, London, England, August 1978.

Publications:

J. D. Shewchuk and R. L. Elsberry, "Improvement of a Baroclinic Typhoon Motion Prediction System by Adjustment of the Initial Wind Field", in Monthly Weather Review, 106, 5 (1978), pp. 713-718.

Thesis Directed:

T. P. Walters, "Improvements in Tropical Cyclone Motion Prediction by Incorporating DMSP Wind Direction Estimates", Master's Thesis, June 1978.

Title: Modeling Upper Ocean Thermal Structure

Investigators: Russell L. Elsberry, Associate Professor of Meteorology and Roland W. Garwood, Jr., Assistant Professor of Oceanography

Sponsor: Naval Ocean Research and Development Activity

Objective: Application of a one-dimensional oceanic boundary layer model for prediction of the upper ocean thermal structure.

Summary: A series of hindcasts with the Garwood model for 17 years at OWS PaPa (50N, 140W) indicates that major changes in ocean thermal structure, as well as many of the synoptic-scale variations, are reasonably well predicted by the model. Computer programs have been written to extract, reformat and edit time series of atmospheric forcing derived from Fleet Numerical Weather Central historical files. The inclusion of salinity on the model has permitted testing (Paulus, M.S. Thesis) in regions of the ocean when the temperature alone does not control the vertical density structure. The paucity of time series of salinity profiles for initializing and verifying the model sensitivity to the atmospheric forcing and the fraction of the anomalous oceanic thermal response that may be attributed to one-dimensional processes.

Conference Presentation: R. L. Elsberry and W. F. Johnson, "Testing a One-Dimensional Ocean Thermal Structure Prediction Model with Operational Data", AGU Annual Fall Meeting, San Francisco, December 1977. Abstract in Transactions American Geophysical Union, 58, 1163.

Thesis Directed: R. A. Paulus, "Salinity Effects in an Oceanic Mixed Layer Model", Master's Thesis, March 1978.

- Title:** Oceanic Thermal Response to Atmospheric Forcing
- Investigators:** Russell L. Elsberry, Associate Professor of Meteorology and Roland W. Garwood, Jr., Assistant Professor of Oceanography
- Sponsor:** Office of Naval Research, Code 481
- Objective:** To understand through observations and numerical model simulations the role of atmospheric forcing of the upper ocean layers.
- Summary:** We have demonstrated (Camp and Elsberry (1978)) that a major fraction of the observed thermal structure changes during the passage of extratropical cyclones can be explained by one-dimensional processes. Furthermore, the rapid transition between a deep winter regime to a shallow regime characteristic of the summer can also be predicted well by the mixed layer models (Elsberry and Garwood (1978)). The distribution of the atmospheric forcing during the warming season (March through August) is very similar to that during the cooling season, although the intensity of the forcing is much less during the warming season (Elsberry and Raney (1978)). These studies indicate that the prediction of sea-surface temperature changes will require a proper representation of both the high wind speed cases and the sustained periods of low wind speeds.
- During the next two years we will attempt to model aspects of hurricane-ocean interaction revealed by new observations (Friese, M. S. thesis), and the interaction of oceanic fronts and vertical mixing processes as suggested by Garwood and Elsberry (1977).
- Conference Presentations:** R. W. Garwood, Jr., and R. L. Elsberry, "Effects of Boundary Layer Processes on the Strength of an Upper Layer Density Front", presented at Chapman Conference on Oceanic Fronts, New Orleans, October 1977. Abstract in Transactions American Geophysical Union, 58.

R. L. Elsberry and W. F. Johnson, "Testing a One-Dimensional Ocean Thermal Structure Prediction Model with Operational Data", presented at the American Geophysical Union Annual Fall Meeting, San Francisco, December 1977. Abstract in Transactions American Geophysical Union, 58, 1163.

R. W. Garwood, Jr., "The Spring Retreat of the Ocean Surface Boundary Layer", presented at AGU Fall Meeting, San Francisco, December 1977. Abstract in Transactions American Geophysical Union, 58, 1156.

Publications:

N. T. Camp and R. L. Elsberry, "Oceanic Thermal Response to Strong Atmospheric Forcing. II The Role of One-Dimensional Processes", Journal of Physical Oceanography, 8, 2 (1978), pp 215-224.

R. L. Elsberry and R. W. Garwood, Jr., "Sea-Surface Temperature Anomaly Generation in Relation to Atmospheric Storms", Bulletin of the American Meteorological Society, 59, 7 (1978), pp 786-789.

R. L. Elsberry and S. D. Raney, "Sea-Surface Temperature Response to Variations in Atmospheric Wind Forcing", Journal of Physical Oceanography, 8, 5 (1978), pp 881-887.

Theses Directed:

L. W. Friese, "Response of the Upper Ocean to Hurricane Eloise", Master's Thesis, December 1977.

R. A. Paulus, "Salinity Effects in an Oceanic Mixed Layer Model", Master's Thesis, March 1978.

Title: Tests of a Mesoscale Numerical Weather Prediction Model Over Europe and the United States

Investigators: G. J. Haltiner, Professor of Meteorology and R. A. Anthes, Adjunct Research Professor of Meteorology

Sponsor: Naval Air Systems Command, Code 370C

Objective: The objective was to adapt and further develop a fine-mesh numerical weather prediction model for application to any part of the globe, particularly the Mediterranean area. The purpose was to improve weather forecasting in areas of operational interest to the Navy by resolving finer scales of motion than presently achieved with the Fleet Numerical Weather Central Northern Hemisphere P.E. model.

Summary: A 60-km, mesh, six-layer model previously programmed by Anthes was adapted and further developed for application to western Europe, particularly the Mediterranean area, and the eastern United States. A total of thirty-two 24-hour forecasts were made for the two areas. The average 24-hour S_1 skill score for sea-level pressure was 39.1 compared to 45.9 for the FNWC operational model and 73.4 for persistence (the lower the score the better the forecast). The model showed considerable skill in forecasting cyclogenesis. Three forecasts and the various physical processes involved are discussed in detail. It appears that further improvements can be made by modifying some of the physics, particularly the latent heat release, and refining the vertical resolution.

Publications: R. A. Anthes, "Tests of a Mesoscale Model Over Europe and the United States", submitted for publication in the Monthly Weather Review.

R. A. Anthes, "Tests of a Mesoscale Model Over Europe and the United States", Technical Report, NPS-63-78-004, August 1978.

Title: Numerical Studies of the Dynamics of Large Scale Ocean Anomalies

Investigator: Robert L. Haney, Associate Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To continually develop and improve a numerical model of the North Pacific Ocean and to use the model to investigate the dynamics of large scale thermal anomalies observed in the North Pacific Ocean.

Summary: The numerical experiments which have been completed (see publications below) conclusively demonstrated the importance of horizontal advection of mean temperature by anomalous wind driven surface (Ekman) currents during the fall and winter of 1976-77 in the central North Pacific. Present work consists of examining the effects of anomalous surface heating during this same winter period and making model improvements to include an explicit prognostic formulation of the well mixed surface layer (Garwood, J. Phys. Oceanogr., 1977).

Conference Presentations:

W. Whiver and R. Haney, "Dynamical-Numerical Prediction of a Large-Scale Thermal Anomaly", paper presented at Fall Meeting AGU, San Francisco, AC, 5-9 Dec 1977.

G. Heise and R. Haney, "A Statistical Study of Synoptic Storm Activity Over the North Pacific", paper presented at Fall Meeting AGU, San Francisco, CA, 5-9 Dec 1977.

Publications:

R. L. Haney, W. S. Shiver and K. H. Hunt, "A Dynamical-Numerical Study of the Formation and Evolution of Large-Scale Ocean Anomalies", J. Phys. Oceanogr., 1978 (in press).

W. B. White and R. Haney, "Seeking the Dynamics of Ocean Climate Variability", Oceanus, 1978 (in press).

R. L. Haney, "Process Parameterization and the Structure of Oceanic General Circulation Models", (submitted for publication).

Title: Mesoscale Atmospheric Events--Antarctica

Investigator: R. J. Renard, Professor of Meteorology

Sponsor: National Science Foundation

Objectives: It is proposed to diagnose mesoscale atmospheric events and their relation to synoptic scale circulations during the Austral summer period over an area surrounding McMurdo, Antarctica, through the analysis of observations taken by weather satellites (visual and infrared), specially-configured aircraft, automatic weather stations and conventional means. The immediate goal is to identify the meso-synoptic scale processes relating to operationally significant weather in the McMurdo area, demonstrating thereby the unique combined use of the aforementioned data sources. Particular attention will be given to katabatic winds, poleward-directed moisture intrusions and regionally-induced thermal/circulation patterns. The longer term goal is to model mesoscale systems associated with significant weather-producing synoptic-scale circulations over a permanent ice/snow covered region of variable elevation and to show the applicability of weather satellite observations, with or without a supporting net of closely spaced stations, to monitor such atmospheric events. Extensions of the mesoscale network to areas other than McMurdo and seasons other than summer is dependent on achieving the immediate goals of the proposal. Project extends through May 1980.

Summary: Following work of the earlier year or two on evaluating remote automatic weather station data from the Antarctic, the current year's effort concentrated on an evaluation of Antarctic data from the Airborne Research Data System (ARDS). These data were gathered aboard a specially configured LC130R aircraft, flown by Antarctic Development Squadron Six (VXE-6) in support of National Science Foundation research programs in the Antarctica and nearby areas. The evaluation consisted of a comparison of wind, temperature and moisture data collected on four flight missions during the period 8-12 November 1977

with data from Antarctic and New Zealand rawinsonde observations as well as 50 kPa analyses from both Fleet Numerical Weather Central, Monterey, California, and the National Meteorological Center, Washington, D. C. The results demonstrated some of the capabilities and limitations of ARDS in logging meteorological data for operational and scientific use. Recommendations for proper conduct of 1978/79 flight missions over the Antarctic were included in this year's report.

**Conference
Presentation:**

R. J. Renard, "Evaluation of Remote Weather Station Data and the Airborne Research Data System in the Antarctica", presented at the U.S. Antarctic Research Program, 1978 Orientation Session, Sheraton National Motor Hotel, Arlington, VA, 17-20 September 1978.

Publication:

R. J. Renard and M. S. Foster, "The Airborne Research Data System: (ARDS) Description and an Evaluation of Meteorological Data Recorded During Selected 1977 Antarctic Flight", Technical Report, NPS-63-78-002, May 1978.

Title: Marine Fog Forecasting

Investigator: R. J. Renard, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To improve the analysis, climatology and forecasting of marine fog over the open ocean and coastal areas. This is a continuing program.

Summary: The program has been divided into three phases: (a) climatology of marine fog frequencies, (b) observation and diagnosis (analysis) of marine fog, and (c) prognosis (forecasting) of marine fog. Although all phases have been researched in the continuing program, phases (b) and especially (c) have been most active in FY 78.

Phase (a):

(1) The climatology of marine fog over the open ocean is considered to be poorly documented. The Naval Postgraduate School (NPS) group has developed a unique approach to deriving marine fog frequencies by synthesizing the information content of the visibility-weather group elements of marine synoptic report into a computerized specification of the percentage of the synoptic reporting period experiencing fog.

(2) Some 12 years of North Pacific ship-report data (over a half million reports, 30-60N) for the major fog season months of June, July, August and September have been processed to derive credible fog frequencies for each 1x1 degree lat/long square; the data have been further stratified to relate frequencies to wind direction and speed on 10x10 degree lat/long squares. As a prototype study, the results have universal application to all ocean areas. The National Climatic Center has already adopted, in part, the approach used here, and has published a new world-wide marine fog climatology (NAVAIR 50-1C-60 CH-1, Sep 1978 Study of Worldwide Occurrence of Fog, Thunderstorms, Supercooled Low Clouds and Freezing Temperatures).

Phase (b):

(1) Until such time that marine-fog areas can be initially specified accurately and completely, the forecasting of marine fog will remain primitive. Conventional ship data, at best sparse, are not adequate. Therefore, weather satellite observations (infrared (IR) and visual) are being researched as a potential prime source of specifying areas of marine fog.

(2) A statistical approach to identifying critical brightness (visual model) and temperature (IR mode) count values associated with marine fog appeared to have promise from earlier prototype work with July 1973 NOAA-2 and 1976 SMS-2 data. Therefore, a more extensive research project has been planned for FY 79. In preparation, GOES-West Satellite data (IR and VIS), 18-03 GMT, 27 Jun - 5 Aug 78, North Pacific Ocean, 35-55N, 120W-180, were retrieved, navigated and archived on computer tape utilizing the McIDAS interaction computer facilities at the Space Science Center, University of Wisconsin, Madison, Wisconsin. In addition, synoptic ship (ground-truth) reports for the period were obtained from Fleet Numerical Weather Central, Monterey, California, with a limited number processed to identify location in the GOES-West Satellite Coordinate System.

Phase (c):

(1) A successful means of forecasting marine fog by computer methods is, in part, dependent on Phases (a) and (b) above, combined with the identification of marine-fog indices compatible with the model output parameters of Fleet Numerical Weather Central, Monterey, California.

(2) Some 38 Fleet Numerical Weather Central (FNWC) model output parameters and climatological fog frequencies (furnished by the National Climatic Center) for the North Pacific Ocean, 30-60N, for June, July and August 1976, have been statistically processed and screened to drive multiple linear regression equations to diagnostically specify marine fog in a probabilistic mode. Threshold probabilities are defined for optimum separation of fog/no fog occurrences. Use of Heidke Skill, Threat and Panofsky-Brier Probability scoring systems on dependent data indicated the regression approach

excels both climatology and the current FNWC operational advection fog prediction scheme, FTER. Using June 1976 equations on July 1976 data, as an independent data set, indicated similar skill.

Conference

Presentations:

R. J. Renard and B. L. Van Orman, "Statistical Diagnostic Modeling on Marine Fog Using Model Output Parameters", 58th Annual Meeting of the American Meteorological Society, Savannah, GA, 29 Jan - 2 Feb 1978, Abstract only, BAMS, Vol 58, #10, Oct 1977, p. 1131.

R. J. Renard, "Observation, Analysis and Prediction of Marine Fog", Program Review for Exploratory Development Program: Atmospheric Environmental Support, Nav Env Pred Res Fac, Monterey, CA, 30-31 Mar 78.

Thesis Directed:

P. F. Quinn, "Further Development of a Statistical Diagnostic Model of Marine Fog Using FNWC Model Output Parameters", Master's Thesis, September 1978.

Title: Numerical Modeling of Air Flow Over Mountains

Investigator: Roger T. Williams, Professor of Meteorology

Sponsor: Fleet Numerical Weather Central

Objective: To develop and test methods for properly treating mountains in numerical forecasting models.

Summary: The numerical model developed by Hayes and Williams (1977) was applied to a long mountain range on a sector of the globe. For small mountain heights the character of the flow did not change as the mountain height was increased. However, when a critical height was reached the air began to flow around the mountain range and new disturbances formed. In this case the smoothing which is used when including topography in numerical models, could lead to a qualitatively different solution and a poor forecast.

A barotropic version of the model was developed for comparison with the finite element model which was developed by Kelley and Williams (1976).

Conference Presentations: R. T. Williams (with J. L. Hayes), "Numerical Simulation of Air Flow Over Mountains", Fall Annual Meeting, American Geophysical Union, San Francisco, Dec 5-9, 1977. Abstract published in Transactions, AGU, 58, 1147.

Title: Global Modeling

Investigator: Roger T. Williams, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objectives: To develop and test numerical procedures for global and regional prediction.

Summary: The research on airflow over a long ridge which was reported by Hayes and Williams (1977) has been extended to higher and more narrow mountain ranges. It was found that when the mountains become sufficiently steep, the character of the airflow will change. The air will tend to flow around the mountain range and new disturbances will be created. This behavior could not be predicted if the mountains were smoothed in the usual way.

Kelley and Williams (1976) tested a barotropic finite element model with variable element sizes. The phase speeds were very accurate, but the model produced considerable noise. Some simple experiments were made to determine the source of the trouble. It is now clear that finite element, primitive equation models, will be noisy if all the variables are carried at the same nodal points. This can be avoided if the fields are properly staggered on different nodal points. A better approach is to use the vorticity and divergence equations in place of the equations of motion.

Conference Presentation: R. T. Williams (with J. L. Hayes), "Numerical Simulation of Air Flow Over Mountains", Fall Annual Meeting, American Geophysical Union, San Francisco, Dec 5-9, 1977. Abstract published in Transactions, AGU, 58, 1147.

DEPARTMENT OF AERONAUTICS

The research effort of the Aeronautics faculty covers a broad range of aeronautics problems with special emphasis on naval aviation problems.

AIRCRAFT COMBAT SURVIVABILITY

Professor Ball has continued his research on the vulnerability of metal and graphite-epoxy aircraft fuel tanks to small arms fire. He continued the development of analytical models and computer programs that adequately describe fuel tank response to penetrating projectiles. Also, he conducted computer studies of aircraft attrition due to anti-aircraft artillery and surface-to-air missiles.

AERODYNAMIC STABILIZATION OF GASEOUS DISCHARGES

Professor Biblarz is investigating practical aerodynamic means for stabilizing discharges for electrical lasers. A particular objective of this program is to study the effects of intense, low frequency turbulence on the discharge.

ELECTRODE LOSS MECHANISMS IN MHD GENERATORS

Professors Biblarz and Ball are investigating the nature and extent of voltage drops in MHD generators and other high-pressure plasma flows. In the vicinity of the electrodes, both the sheath and the boundary layer contribute to the voltage loss. Non-emitting electrodes are being studied.

MARKS' ELECTROTHERMODYNAMIC GENERATOR

Professors Biblarz and Gawain are conducting a theoretical research effort complementary to the Marks' Polarized Corporation test program in order to help interpret and document results of generator tests.

LASER DOPPLER VELOCIMETER MEASUREMENTS IN A TRANSONIC COMPRESSOR

Professor Collins is measuring the exit flow field of a transonic compressor rotor using laser doppler velocimetry. These measurements are being coordinated with holographic interferograms of the interblade flow field.

SURFACE EFFECT SHIP TECHNOLOGY TESTCRAFT

Professor Layton is conducting a systematic test program to determine the seal loads on the manned model testcraft XR-3 under varying conditions of loading, center of gravity, seal shape, seal position and turning performance.

DUAL CHAMBER ROCKET

Professors Gawain and Netzer are performing experimental and theoretical investigations of the gas dynamic behavior within the dual-chamber configuration to obtain a sufficient data base and understanding which can be used to determine concept feasibility.

PIPE FLOW STABILITY

Professor Gawain has re-examined the problem of pipe flow stability and has developed a new analysis which successfully accounts for the experimentally observed instabilities. Extensive calculations for various wave numbers are being made to explore the full-implications of the theory.

AIRCRAFT FATIGUE STUDIES

Professor Lindsey is working on aircraft fatigue problems directed toward fleet fatigue life monitoring. He is developing methods of data reduction for the aircraft fatigue monitoring devices currently being prototyped using microprocessor technology.

SOLID FUEL RAMJETS

Professor Netzer is developing an interior ballistics model for the solid fuel ramjet and is conducting experiments to examine the effect of unburned carbon on combustion efficiency.

JET ENGINE TEST CELL EMISSION CHARACTERISTICS

Professor Netzer is determining the emission levels and air quality effects from Naval Air Station aircraft operations and test cells. This project involves the development of an air quality assessment model for U. S. Navy operations. The

effects of test cell design and engine operating characteristics on pollutant concentrations in the exhaust stack are being determined experimentally and a computer model is being developed to predict the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell, augmentor and exhaust stack.

VSTOL AIRCRAFT/PROPULSION SYSTEM STUDIES

Professor Platzer is performing technology assessment and feasibility studies of VSTOL aircraft and propulsion systems. Also, the analysis of the unsteady flow and flutter characteristics of transonic compressors is being continued.

TRANSONIC COMPRESSOR STUDIES

Professor Shreeve is conducting a program of measurements, using the transonic compressor test rig of the Naval Postgraduate School, to determine the flow phenomena occurring in transonic axial compressor bladings in order to appraise and improve analytical models for steady and non-steady effects. Instrumentation includes rakes and fixed probes at stage inlet and outlet, traversing probes, pneumatic static taps in case and hub walls, and measurements of torque and speed. Real time and steady-state data are required using a dedicated mini-computer system.

CIRCULATION CONTROL ROTOR AERODYNAMICS

Professors Schmidt and Miller completed a project to determine the unsteady aerodynamics of a circulation control airfoil (CCA) when the Coanda sheet formed at the trailing edge is oscillated about a mean value by varying the momentum blowing coefficient. The aerodynamic transfer functions were experimentally determined for a 21% thick elliptical airfoil.

GUIDED PROJECTILE FIN DYNAMICS

Professor Schmidt is analyzing the fin-opening dynamics for an 8-inch gun launched extended range guided projectile

during ejection from the gun barrel. The influence of fin elasticity is included in the dynamic modelling.

being done and experimentally and a computer model is being developed to predict the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell, separator and exhaust stack.

VECTOL AIRCRAFT PROPULSION SYSTEM STUDIES

Professor Finkbeiner is performing technology assessment and feasibility studies of VECTOL aircraft and propulsion systems. Also, the analysis of the unsteady flow and fin interaction characteristics of ramjet compressors is being continued.

TRANSONIC COMPRESSOR STUDIES

Professor Finkbeiner is conducting a program of measurements using the transonic compressor test rig of the Naval Postgraduate School to determine the flow phenomena occurring in transonic axial compressor blades in order to appreciate and improve analytical models for steady and non-steady effects. Instrumentation includes static and total pressure at stage inlet and outlet, traversing probes, pneumatic static taps in case and hub walls, and measurements of torque and speed. Real time and steady-state data are required using a dedicated min-computer system.

CIRCULATION CONTROL MOTOR AERODYNAMICS

Professors Finkbeiner and Miller completed a project to determine the unsteady aerodynamics of a circulation control airfoil (CCA) when the Gurney flaps formed at the trailing edge is oscillated about a mean value by varying the momentum blowing coefficient. The aerodynamic transfer functions were experimentally determined for a NACA 0012 airfoil.

GUIDED PROJECTILE FIN DYNAMICS

Professor Schmidt is analyzing the fin operating dynamics for an 8-inch gun launch and extended range guided projectile.

Title: Axial Compressor Flow Fields

Investigator: Dan Adler, Naval Air System Command,
Visiting Research Professor of
Aeronautics

Sponsor: Office of Naval Research, Power Program

Objective: To obtain an improved understanding of
the flow fields in axial compressors
in order to formulate and evaluate ana-
lytical prediction models.

Summary: It is proposed to determine the velocity
field at the exit of an axial rotor us-
ing a simple system of two semi-conductor
impact probes and a semi-conductor Kiel
probe with digital "synchronised sam-
pling." A computational technique to
evaluate velocity vector from the three
probe system has been worked out, based
on five measurements for each data point.
Emphasis was given to simplify the ex-
periments in order to minimize possible
errors and experiment duration. Com-
puter time required is between one to
five seconds on an IBM 360 for most cases,
up to two minutes for a few cases in
which convergence difficulties do occur.
Convergence, however, is ensured in all
possible cases. This makes the technique
a reliable experimental tool.

Title: Aircraft Combat Survivability Studies

Investigator: Robert E. Ball, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command (JTTCG/AS)

Objectives:

- 1) To continue the development of analytical models and computer programs that adequately describe fuel tank response to penetrating projectiles, and to develop a manual containing fuel tank damage estimates that can be used by a fuel tank designer.
- 2) To determine experimentally and theoretically the failure mechanisms and carrying capacity of graphite-epoxy composite fuel tank walls attached to ribs and spars with metal fasteners and subjected to hydraulic ram loading.

Summary:

- 1) Metal aircraft fuel tanks subjected to ballistic impact and penetration by small arms fire and missile fragments can be severely damaged, with large petalling of the tank walls occurring at the entrance and exit points of the projectile. The damage mechanism, called hydraulic ram, is a very high pressure wave in the fuel caused by the passage of a ballistic penetrator through the fuel. An analytical and experimental hydraulic ram program has been in existence at the Naval Postgraduate School (NPS) for over five years. Fluid pressures and wall strains have been experimentally measured and analytically predicted at NPS for rectangular tanks with aluminum walls.

In this reporting period, the piston theory that accounts for the fluid-structure interaction was replaced with a finite difference routine that computes the pressure throughout the fluid volume due to tank wall motion. This routine was incorporated into the structural response code SATANS and comparisons of tank wall motion were made with the results from a study by California Research Technology. Good agreement between the results was noted. With regard to the

second objective, a format for the fuel tank damage manual was proposed.

2) This is the first phase in a program to determine the combat damage induced failure of graphite-epoxy composite structures in aircraft fuel tanks. Two studies have now been completed. In one, the relationship between the bending moment and the through-plane shear force in the vicinity of a mechanical fastener at failure was determined experimentally. The connection was similar to the connection planned for use on the F-18 composite wing and the AV-8B composite wing and fuselage fuel tanks. Two analyses were also made. In the second study, the reduction in ultimate bending moment due to an internal delamination was determined experimentally for several locations of the delamination and for two sizes of delaminations. The extent of damage to the F-18 simulated composite wing box due to small arms fire tests conducted by the Naval Weapons Center was also briefly examined. Continued work is planned for the coming year.

Theses Directed:

R. C. Sprigg, "An Experimental Study to Determine the Reduction in Ultimate Bending Moment of a Composite Plate Due to an Internal Delamination", Master's Thesis, December 1977.

R. A. Eason, "Computer Studies of Aircraft Fuel Tank Response to Ballistic Penetrators", Master's Thesis, March 1978.

Title: Aerodynamic Stabilization of Gaseous Discharges

Investigator: Oscar Biblarz, Associate Professor of Aeronautics

Sponsor: Foundation Research Program (6.2)

Objective: The main objective is to define practical aerodynamic means for stabilizing discharges for electrical lasers; other applications in cold plasma chemistry are also envisaged. A particular objective was to study the effects of intense, low frequency turbulence on the discharge. This is part of a continuing program.

Summary: A new technique for producing intense, low frequency turbulence has been introduced. This technique consists of utilizing a mixing region produced by an oscillating auxiliary flow which is injected into the main flow. Here, both the intensity and the frequency of turbulence are highly controllable. The project will continue with the evaluation of the effects of this turbulence on the discharge.

Conference Presentations: E. Wassertrou, Y. Crispin and O. Biblarz, "Stabilization of Glow Discharges by Supersonic Flows", presented at the 30th Annual Gaseous Electronics Conference, 18-21 October 1977, Palo Alto, CA, Program and Abstracts/30th Annual GEC.

O. Biblarz, "A Re-examination of the Classical Solution to the Positive Column of a Glow Discharge", presented at the 1978 IEEE International Conference in Plasma Science, 15-17 May 1978, Monterey, CA, IEE Conference Record-Abstracts.

Publication: Y. Khait and O. Biblarz, "Influence of Turbulence on a Diffuse Electrical Gas Discharge Under Moderate Pressures", accepted for publication in the Journal of Applied Physics.

Title: Study of Marks' Electrothermodynamic (ETD) Generator

Investigators: Oscar Biblarz, Associate Professor of Aeronautics and T. H. Gawain, Professor of Aeronautics

Sponsor: U. S. Department of Energy

Objectives: To conduct a theoretical research effort complementary to the Marks' Polarized Corporation test program, to do diagnostic experiments on droplet viability, and to help interpret and document results of generator tests.

Summary: This is a new program which was negotiated in FY 78 but which begins in FY 79.

Title: Electrode Loss Mechanisms in MHD Generators

Investigators: Oscar Biblarz, Associate Professor of Aeronautics and R. E. Ball, Associate Professor of Aeronautics

Sponsor: Air Force Office of Scientific Research

Objective: The principal objective is to define the nature and extent of voltage drops in MHD generators and other high pressure plasma flows. In the vicinity of the electrodes, both the sheath and the boundary layer contribute to the voltage loss. Non-emitting electrodes are being studied. This is a continuing report.

Summary: The Newton-Raphson technique was introduced and calculations for higher potentials carried out. The larger currents produce enough Joule heating for ionization to take place and solutions for a reacting plasma are being attempted.

Publications: R. C. Dolson and O. Biblarz, "A Simplified Technique for Determining the Boundary Layer Voltage Loss in MHD Generators", Energy Conversion, Vol. 16, 1977, pp 205-211.

Conference Presentation: R. E. Ball and O. Biblarz, "The MHD-Sheath Voltage Drop, Effect of Higher Currents", presented at the 1978 IEEE International Conference on Plasma Science, 15-17 May 1978, Monterey, California, IEEE Conference Record-Abstracts.

Patent Application: O. Biblarz, "Staircase Electrode for MHD Generators", submitted a disclosure.

Title: Laser Doppler Velocimeter and Holographic Studies of a Transonic Compressor

Investigator: Daniel J. Collins, Professor of Aeronautics

Sponsor: Naval Air Systems Command, Code 310

Objective: Quantitative velocity measurements in a transonic compressor - supplemented by holographic interferometry of the entire flow field.

Summary: Velocity traverses have been made of both axial and tangential components in the wake of the rotor blades using the LDV equipment. After suitable modification of casing further measurements will be made interblade of the rotor.

Thesis Directed: J. Harrison, "LDV Measurements in a Transonic Compressor," Master's Thesis, December 1978.

Title: A Basic Reformulation of the Pipe Flow Stability Problem

Investigator: T. H. Gawain, Professor of Aeronautics

Sponsor: Foundation Research Program (6.1)

Objective: In pioneering experiments performed nearly one hundred years ago, Osborne Reynolds showed that pipe flow is stable only below a certain critical Reynolds number. Classical theories have failed to predict or explain these observed instabilities. This research re-examines the problem from first principles and explains the former discrepancies. Of particular importance is the proper formulation of the complex boundary conditions at the pipe axis. This problem has now been solved rigorously. Typical calculations for wave number zero support the new theory. Extensive calculations for other wave numbers will be required to explore the full implications of the theory.

Publications: T. H. Gawain, "A Basic Reformulation of the Pipe Flow Stability Problem and Some Preliminary Numerical Results," Technical Report NPS 67-78-006, September 1978.

Thesis Directed: M. J. Arnold, "Investigation of Pipe Flow Instability and Results for Wave number Zero," Master's Thesis in Aeronautical Engineering, December 1978.

Title: Operating Characteristics of the Dual Chamber Rocket

Investigators: T. H. Gawain, Professor of Aeronautics and D. W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Weapons Center, Code 3245, D. P. Wirtz

Objective: Perform experimental and theoretical investigations of the gas dynamic behavior within the dual-chamber configuration to obtain a sufficient data base and understanding which can be used to determine concept feasibility.

Summary: An experimental investigation was conducted using cold flow simulation of the dual chamber rocket. The effects of booster cavity length, shockdown pressure, nozzle area ratios, and aft nozzle removal on thrust and pressure distribution were determined. With the booster nozzle attached it was found that thrust did not vary significantly with booster cavity length although cavity static pressure decreased rapidly for cavities shorter than 20 jet diameters in length. No configurations were found which could substantially decrease the stagnation pressure losses associated with shockdown. Current work is directed at additional nozzle area ratios and 2-D schlieren studies of the booster cavity flow field during sustainer operation.

In connection with the development of a dual chamber rocket, the need arose for a mathematical model capable of simulating the flow field involved. The flow is turbulent and includes supersonic, subsonic and recirculating regions. A model was developed for the flow field that results with the booster nozzle removed. Turbulence effects were accounted for by an eddy viscosity hypothesis, and by suitable coefficients of mass, energy and entropy transport. It was found that

these turbulence effects radically change the elliptical/hyperbolic characteristics of the equations as compared with the classical case of nonturbulent compressible flow. The equations of momentum, continuity and energy for turbulent flow were shown to be elliptical for both supersonic and subsonic regions. When the second law of thermodynamics was added, the equations assumed a parabolic character.

Publications:

T. H. Gawain, "A Mathematical Model for Turbulent Flows Involving Supersonic, Subsonic and Recirculating Regions", Technical Report, NPS67Gn 78003, July 1978.

J. F. McFillin, Jr. and D. W. Netzer, "An Experimental Investigation of the Dual Chamber Rocket", Technical Report, NPS 67-78-011, December 1978 (in preparation).

Thesis Directed:

J. F. McFillin, Jr., "An Experimental Investigation of the Dual Chamber Rocket", Master's Thesis, June 1978.

Title: Surface Effect Ship Technology Testcraft Program

Investigator: D. M. Layton, Associate Professor of Aeronautics

Sponsor: Naval Sea Systems Command

Objective: Determination of seal loads on the manned model testcraft XR-3 under varying conditions of loading, center of gravity, seal shape, seal position and turning performance.

Summary: Aero and hydro forces on both the bow and stern seals have been examined and reported during this period. Experimental tests have begun to determine the effects of bow seal shape and position on the seal lift and drag, and the effects of turning performance on the differential drag of the bow seal.

Publications: D. M. Layton, "Seal Loads of the Surface Effect Ship Testcraft XR-3", Project Report, NPS 67-78-001PR, November 1977.

Conference Presentations: D. M. Layton, "XR-3 Surface Effect Ship Testcraft Operations", a movie shown at the AIAA/SNAME Advanced Marine Vehicles Conference, San Diego, California, April 1978.

Theses Directed: J. A. Fjelde and C. E. Gaenslen, "XR-3 Bow Seal Performance as a Function of Seal Geometry", Master's Theses, December 1978.

D. Edwards, "Bow Seal Loads of the XR-3 Testcraft in Turns", Master's Thesis, December 1978.

Title: Aircraft Fatigue Studies

Investigator: G. H. Lindsey, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop methods of data reduction for the aircraft fatigue monitoring devices currently being prototyped, using microprocessor technology.

Summary: With new aircraft fatigue monitoring instruments under development, it is appropriate to investigate methods whereby the data from them can be used to make damage calculations. Three areas have been studied: (1) calculation of local stress at the stress riser from far-field strain-gage measurements via modified Neuber's equations, (2) determination of the magnitude of residual stress remaining at the stress riser at the end of each cycle, and (3) the relaxation behavior of compressive residual stress at the stress riser. Results have been obtained in all three areas and work in areas (2) and (3) will be carried further this year.

Publications: G. H. Lindsey, "Research on Fatigue of Aircraft Structures", Project Report, NPS 67-78-004PR, August 1978.

Theses Directed: F. M. Blakely, Jr., "Design of Software Package for Incorporation of Random Load Testing and Data Processing on Materials Testing System Machine", Master's Thesis, June 1978.

L. D. Newsome, "Fatigue Crack Propagation Analysis of Aircraft Structures", Master's Thesis, March 1978.

Title: Use of Sulphur-Hexaflouride as a Leak Detector for Buried Steam Lines

Investigator: J. A. Miller, Associate Professor of Aeronautics

Sponsor: Naval Construction Battalion Center

Objective: To develop a procedure for locating leaks in the outer barrier of buried Rikwel steam lines.

Summary: This project is basically to provide consulting engineering services to the Mechanical Equipment Department of the Naval Civil Engineering Laboratories. A field procedure is being developed to employ sulphur hexaflouride to trace leaks in the outer barrier of buried Rikwel steam lines using relatively inexpensive ion-capture instrumentation. Sulphur hexaflouride was chosen as a highly electronegative and thus easily detected as well as inert tracer gas. Local measurements of the diffusivity of sulphur hexaflouride are being made in a variety of soil samples representative of allowable backfill materials in order to predict optimum dwell times for the tracer gas. Approximately ten days further testing remains to be completed prior to drafting the first field manual. An in situ test at Port Hueneme is planned for early summer 1979.

Publications: A Naval Civil Engineering Laboratory Field Manual will result from the present work as well as an open literature paper on the Transactions of the ASME, Journal of Engineering for Power.

Thesis Directed: No theses will result from this work however the diffusivity measurements are serving as an ME 4902 project for LT James A. Hill.

Title: Emission Levels and Air Quality Effects from Naval Air Station Aircraft Operations and Test Cells

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Air Propulsion Center, Code PE71, A. Klarman

Objectives:

- a) Develop and experimentally validate a computer model which can be used to assess the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell, augmentor and exhaust stack.
- b) Experimentally determine the effects of test cell design and engine operating characteristics on pollutant concentrations in the exhaust stack.
- c) Develop an air quality assessment model for U.S. Navy operations. This is a continuing project.

Summary:

The initial effort was directed at developing computer models which could be used to assist in the design and/or modification of test cells. Initial models were developed and subsequently validated in a one-eighth scale test cell which has been constructed at the Naval Postgraduate School. The initial computer models were limited to low subsonic exhaust conditions. Current efforts are being directed at models which will be applicable through afterburning conditions.

The subscale test cell has also been utilized to perform a study of the effects of engine operating conditions and cell design on dry-augmentor performance. The current effort is directed at experimental determination of the effects of test cell design, engine operating conditions and fuel additives on the quantity and composition of emitted particulates. Measurements with commercially avail-

able transmissometers are also being made and compared to quantitative data on particulate size, concentration, and composition. Measurements are being made at engine and stack exhaust locations.

An additional effort has been directed at adaptation of the U.S. Air Force AQAM to Naval air operations. Model modifications have been completed and the sensitivity of model predictions to meteorological and operational variables has been determined. Specific application of the modified model has been directed at NAS Miramar, CA.

Model validation efforts at NAS Miramar are currently being conducted (following the Air Force validation effort at Williams AFB) in conjunction with the EPA. The model was used to help in the site selection process. A possible weakness of the model has been observed in the Williams AFB effort and by other related efforts. Dispersion of aircraft jet exhaust plumes during taxi and take-off does not appear to be adequately modeled except for limiting meteorological conditions. Needed experimental data is practically non-existent. Current efforts are directed at the above mentioned areas.

Dispersion rates are being measured as a function of meteorological conditions and jet exhaust velocity, direction, and temperature. These measurements are being conducted under simulated neutrally stable atmospheric conditions in the large, low speed wind tunnel at the Naval Postgraduate School. Results of the study will be incorporated into AQAM as appropriate.

Publications:

K. I. Weal, G. R. Thompson, and D. W. Netzer, "Modification of an Ambient Air Quality Model for Assessment of U.S. Naval Aviation Emittants," Air Pollution Control Association Journal, 28, 3 (1978) pp. 247-248.

J. J. Walters and D. W. Netzer, "A Validation of Mathematical Models for Turbojet Test Cells", Technical Report, NPS 67-78-002, June 1978.

D. W. Netzer, "Sensitivity of AQAM Predictions for Naval Air Operations to Meteorological and Dispersion Model Parameters", Technical Report, NPS67NT78051, May 1978.

C. N. Sapp, Jr., and D. W. Netzer, "Experimental Investigation of Turbojet Test Cell Augmentors", Technical Report, NPS 67-78-009, September 1978.

Theses Directed:

C. N. Sapp, Jr., "An Experimental Investigation of Turbojet Test Cell Augmentors", Master's Thesis, June 1978.

J. R. Charest, "Combustor Design and Operation for a Sub-scale Turbojet Test Cell", Master's Thesis, March 1978.

J. J. Walters, "A Validation of Mathematical Models for Turbojet Test Cells", Master's Thesis, March 1978.

Title: Interior Ballistics of Solid Fuel Ramjets

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Weapons Center, Code 3246, F. Zarlingo

Objective: To develop an interior ballistics model for the solid fuel ramjet and to experimentally examine the effect of unburned carbon on combustion efficiency. This is a continuing project.

Summary: Light extinction measurements were employed to study the effect of fuel composition and bypass ratio on the combustion efficiency and the percent and size of unburned carbon. It was found that the percentage of unburned carbon did not correlate with combustion efficiency and that variations in fuel manufacturing processes (cure, etc.) can significantly change the combustion behavior. Optimum fuels for the solid fuel ramjet appear to be those which can yield both high regression rates and monomer decomposition.

Current modeling work is directed at a primary variable computer code. The aft mixing chamber flow field is being modeled and comparisons with the earlier stream function - vorticity code are being made.

Publications: D. W. Netzer, "Modeling Solid-Fuel Ramjet Combustion," Journal of Spacecraft and Rockets, 14, 12 (1977) pp. 762-766.

C. J. Mady, P. J. Hickey, and D. W. Netzer, "Combustion Behavior of Solid-Fuel Ramjets," Journal of Spacecraft and Rockets, 15, 3 (1978) pp. 131-132.

D. W. Netzer, "Model Applications to Solid-Fuel Ramjet Combustion," Journal of Spacecraft and Rockets, 15, (1978) pp. 263-264

M. E. Hewett and D. W. Netzer,
 "Application of Light Extinction
 Measurements to the Study of Com-
 bustion in Solid Fuel Ramjets",
 Technical Report, NPS 67-78-008,
 November 1978.

**Conference
 Presentations:**

D. W. Netzer, "Application of Light
 Extinction Measurements to the
 Study of Combustion in Solid Fuel
 Ramjets", presented at the 15th
 JANNAF Combustion Meeting, Newport,
 RI, 11-15 September 1978.

Thesis Directed:

M. E. Hewett, "Application of Light
 Extinction Measurements to the
 Study of Combustion in Solid Fuel
 Ramjets", Master's Thesis, June 1978.

Title: Investigation of Unsteady Transonic Compressor Flows

Investigators: M. F. Platzter, Professor of Aeronautics and K. Vogeler, Adjunct Research Professor of Aeronautics

Sponsor: Foundation Research Program (6.2)

Objective: To develop theoretical solutions for supersonic/transonic flow past oscillating compressor cascades with finite blade thickness.

Summary: A method of characteristics solution was developed based on the nonlinear transonic small perturbation equation to compute the pressure distributions, forces and moments on oscillating compressor cascades with finite blade thickness. Program documentation and representative computational examples are given.

Publications: K. Vogeler, "A Method of Characteristics Approach to Supersonic Flow Past Oscillating Cascades with Finite Blade Thickness", NPS Report to be published soon.

Title: Investigation of VSTOL Propulsion Problems

Investigator: M. F. Platzer, Professor of Aeronautics

Sponsor: Naval Air Systems Command, Code AIR-310A,
Dr. H. J. Mueller

Objectives: To perform feasibility studies of various VSTOL propulsion concepts, and to investigate the unsteady flow/aeroelastic characteristics of transonic turbomachines.

Summary: The study of the aeroelastic characteristics of supersonic cascades including nonlinear thickness and shock effects has been completed. Also, the potential of unsteady jet flow effects to increase entrainment rates in thrust augmenting ejectors has been experimentally demonstrated.

It is planned to continue the above studies with special emphasis on the experimental verification of the transonic blade flutter characteristics and on the VSTOL propulsion feasibility studies.

Publications: J. M. Simmons, M. F. Platzer and T. C. Smith, "Velocity Measurements in an Oscillating Plane Jet Issuing into a Moving Airstream," Journal of Fluid Mechanics, Vol. 84, Part 1 (1978) pp. 33-53.

M. F. Platzer and R. J. Margason, "Prediction Methods for Jet VSTOL Propulsion Aerodynamics," Journal of Aircraft, Vol. 15, No. 2, February 1978, pp. 64-77.

J. M. Simmons and M. F. Platzer, "Entrainment Characteristics of Unsteady Subsonic Jets," American Institute of Aeronautics and Astronautics, Vol. 16, No. 3, March 1978, pp. 282-284.

J. M. Simmons and M. F. Platzer, "A Quasi-Steady Theory for Incompressible Flow past Airfoils with Oscillating Jet Flap," American Institute of Aeronautics and Astronautics, Vol. 16, No. 3, March 1978, pp. 237-241.

J. A. Strada, W. R. Chadwick and M. F. Platzer, "Aeroelastic Stability Analysis of Supersonic Cascades", accepted for publication in ASME Journal of Engineering for Power.

**Conference
Presentations:**

M. F. Platzer with R. J. Margason, "Unsteady Flows in Turbomachines - A Review of Current Developments", presented at the AGARD Symposium on Unsteady Aerodynamics, Ottawa, Canada, 26-28 September 1977, AGARD CP-227, pp 33-1 to 33-28.

M. F. Platzer with J. A. Strada and W. R. Chadwick, "Aeroelastic Stability Analysis of Supersonic Cascades", ASME-paper No. 78-GT-151, presented at the Gas Turbine Conference, London, England, 9-13 April 1978.

M. F. Platzer with J. M. Simmons and K. Bremhorst, "Entrainment Characteristics of Unsteady Subsonic Jets", presented at the Workshop on Thrust Augmenting Ejectors, NASA-Ames Research Center, Moffett Field, California, 28-29 June 1978, to be included in the workshop proceedings.

Theses Directed:

John C. Ball, "The Feasibility of the Jet-Flap Rotor as a Lift Generator for Vertical Takeoff and Landing Aircraft", Master's Thesis, December 1977.

Arne B. Bruflat, "User's Manual for ACSUNT - A Computer Program for Aircraft Synthesis", Master's Thesis, December 1977.

Brendan J. O'Donnell, "Application of the ACYNT Computer Program for Aircraft Design to VSTOL Aircraft", Master's Thesis, March 1978.

Peter C. Olsen, "Theoretical Analysis of Transonic Flow Past Unstaggered Oscillating Cascades", Aeronautical Engineer's Thesis, September 1978.

Title: CCR Unsteady Aerodynamics

Investigators: Louis V. Schmidt (Principal), Professor of Aeronautics
James A. Miller (co-investigator), Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command
Code AIR-320D

Objective: To determine the unsteady aerodynamics of a Circulation Control Airfoil (CCA) when the Coanda sheet formed at the trailing edge is oscillated about a mean value by varying the momentum blowing coefficient. The initial goal was the experimental evaluation followed by a theoretical estimation. The study effort is in support of NAVAIR sponsored technology demonstration program wherein the overall concept has an end-product goal of improving both performance and reliability of rotorcraft vehicles.

Summary: Aerodynamic transfer functions applicable to the CCA for the situation of harmonic blowing perturbations superimposed upon a mean cavity pressure were experimentally obtained for a 21.4 percent thick elliptically shaped two-dimensional airfoil. The results identified the behavior of Coanda sheet dynamics, airfoil lift transfer function and airfoil damping moment.

Research program completed. Further tests in the 2x2 foot wind tunnel not considered due to adverse flow conditions.

Publications: L. V. Schmidt, "Circulation Control Airfoil Study. Progress Report No. 4," Technical Report NPSy57Sx-77111, November 1977.

L. V. Schmidt, "Oscillating Plain Flap Analogy for Unsteady Aerodynamics of a Circulation Control Airfoil," NPS Memo, 4 January 1978. (sent to the sponsor)

Conference
Presentation:

L. V. Schmidt, "Unsteady Aerodynamics of a Circulation Controlled Airfoil", presented at the Fourth European Rotorcraft and Powered Lift Aircraft Forum, Stresa, Italy, September 1978, Paper No. 12.

Thesis Directed:

C. G. Bogino, "Initial Steady Aerodynamic Measurements of a Circulation Control Airfoil in an Oscillating Flow Wind Tunnel", Master's Thesis, December 1978.

Title: VSTOL Aerodynamics

Investigators: L. V. Schmidt and R. W. Bell, Professors
of Aeronautics

Sponsor: Naval Air Systems Command

Objective: Model the VSTOL jet reaction flow field including the presence of the aircraft shape, ground effect, cross winds and multiple jet configurations; increase the predictive capability of VSTOL related flow phenomena such as suckdown, hot gas reingestion and entrainment. These latter effects have a significant impact upon design analysis and evaluation for future Navy VSTOL aircraft.

Summary: New start.

Title: Velocity Field Measurements in Compressors

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Foundation Research Program (6.1)

Objective: To develop a technique to obtain time-resolved velocity fields between rotors and stators.

Summary: The technique of "synchronised sampling" was developed and applied with a semiconductor (Kulite) impact probe at the exit of an axial (impulse) rotor. The distribution of the flow yaw angle on the annulus centerline across the exit of two chosen pairs of blade passages were measured. The flow through the wakes of the blades and the differences between the flows from the individual passages were resolved. On-line calibration to pneumatic-equivalent probes was verified as a technique to overcome transducer temperature sensitivity and drift problems.

Thesis Directed: K. A. Winters, "Development of a Method of Measuring Velocity at the Exit of a Compressor Rotor Using Kulite Probes with Synchronised Sampling", Master's Thesis, March 1978.

Title: Transonic Compressor Investigations

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: The overall objective of this continuing program is to determine by measurement the behavior of the flow through transonic axial compressor bladings in order to appraise and improve predictive analytical models for steady and unsteady effects. Better predictive methods are needed to improve the design and reduce the development time of new jet engines.

Summary: Diagnostic measurements of various kinds have been made in a small axial compressor stage operating to transonic speeds. Fixed instrumentation was used first to determine stage performance and exit flow behavior. Probe techniques were developed and surveys were made to determine rotor blade element performance. Kulite sensors in the case wall were used with "synchronised sampling" to determine case wall pressure signatures through the rotor blade passage. A two-dimensional cascade model of the relative flow at the rotor tip at $M = 1.4$ was constructed and initial check-out was completed. Data from the compressor will now be extended to supersonic relative conditions and a comparison of the case wall pressure contours with cascade measurements and schlieren observations will be made. The validity of the design model can then be appraised.

Publications: R. P. Shreeve, "Real-Time Measurements in a Transonic Compressor," Transonic Flow Problems in Turbomachinery, Ed. T.C. Adamson, Jr., and M. F. Platzer, Hemisphere Publication Corp., (1977).

J. M. Simmons, and R. P. Shreeve, "Data Acquisition and Analysis Techniques for Measurement of Unsteady Wall Pressures in a Transonic Compressor," Technical Report, NPS-67Sf7701, July 1977.

R. P. Shreeve, D. J. Anderson and J. A. Olson, "Velocity Vector Determination from Multiple-Sensor Pneumatic Probe Measurements", AIAA Journal, Vol. 15, No. 11, November 1977.

Conference
Presentations:

R. P. Shreeve, F. J. Dodge, W. R. Hawkins, and V. J. Larson, "Probe Measurements of Velocity and Losses from a Small Axial Transonic Rotor", presented at the AIAA 11th Fluid and Plasma Dynamics Conference, AIAA Paper 78-1198, Seattle, Washington, 10-12 July 1978.

R. P. Shreeve, J. M. Simmons, K. A. Winter, and J. C. West, Jr., "Determination of Transonic Compressor Flow Field by Synchronised Sampling of Stationary Fast Response Transducers", presented at the Symposium on Non-Steady Fluid Dynamics, ASME 1978 Winter Annual Meeting, San Francisco, California, December 1978, also submitted for publication to ASME Journal of Fluids Engineering.

Thesis Directed:

W. J. Demo, Jr., "Cascade Wind Tunnel for Transonic Compressor Blading Studies", Master's Thesis, June 1978.

Title: Development of a Transonic Compressor Model

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop a small transonic axial air compressor model and establish methods of measuring the performance and flow behavior in small machines.

Summary: A 450 HP single stage transonic axial compressor has been developed and operated to 22,000 RPM, or 70 percent design speed. Testing to design speed will flow development of techniques for measuring details of the aerodynamic performance of the blading and the occurrence of blade flutter. A new combination probe was developed and used to determine the time-average blade element performance of the rotor. Techniques for non-steady pressure measurements are under development using a new technique and computer peripheral device. Apparatus to detect blade vibration optically during operation has been installed.

Publications: R. P. Shreeve, "Probes and Measurement Techniques from Tests of a Small Transonic Compressor," AIAA Paper 78-969, AIAA/SAE 14th Joint Propulsion Conference, Las Vegas, Nevada, July 25-27, 1978.

Title: Small Turbine Blade Row Performance Measurements

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Un-sponsored

Objective: To determine by test rig measurements the losses occurring in the individual blade rows of a single stage axial transonic turbine, and to evaluate the rig as a possible tool for small turbine injection-cooling and variable geometry experiments.

Summary: A test rig for single stage axial air turbines has been developed for subsonic and supersonic stages producing less than 300 horsepower. The rig is instrumented to allow stator and rotor blade row losses to be calculated separately from measurements of torques, forces, temperatures and pressures. The losses measured for the stator of a transonic turbine were higher, and for the rotor, lower than predicted. A computer program for the flow through the stage was written, and it was found that the measured losses allowed a solution consistent with the measured performance, whereas the predicted loss values did not. A new water-brake dynamometer was installed, and tests were carried out to measure the effect of axial clearance on the individual blade row losses, to further assess the application of the test rig.

Thesis Directed: W. J. Kane, "Experimental Investigation of the Effect of Rotor-to-Stator Axial Spacing on the Performance of a Single Stage Transonic Axial Turbine," Master's Thesis, March 1978.

Title: Axial Compressor Flow Fields

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Office of Naval Research, Power Program

Objective: To obtain an improved understanding of the flow fields in axial compressors in order to formulate and evaluate analytical prediction models.

Summary: It is proposed to determine the velocity field at the exit of an axial rotor using a simple system of two semi-conductor impact Probes with digital "synchronised sampling." The method follows completed work in which the distribution of flow yaw angle on the annulus centerline across the exit of chosen rotor blade passages was measured using a single probe. A comparison of the measurements with LDV measurements of the same flow field is planned. Analytical techniques to evaluate velocity vector from the two probe system have been worked out.

Thesis Directed: K. A. Winters, "Development of a Method Measuring Velocity at the Exit of a Compressor Rotor Using Kulite Probes with Synchronised Sampling", Master's Thesis, March 1978.

DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under four headings according to the facilities utilized and the sources of data. These headings are: (1) ship programs, (2) coastal studies, (3) deep ocean data analyses, and (4) special studies.

SHIP PROGRAMS

The investigators in this category make use of the Naval Postgraduate School research vessel ACANIA, a ship supported by the Oceanographer of the Navy; also, some investigations make use of other ships. The first of these studies is that conducted by J. B. Wickham, and S. P. Tucker. Their present observational effort in the continuing study of the California Countercurrent has two parts: (1) A year's continuous monitoring of the core of the countercurrent with an array of moored current meters and sensors of water mass properties, and (2) A broader monthly sensing of the region of the countercurrent with densely spaced continuous profiling of the water mass properties. The region of interest is one of relatively uncluttered sea floor topography on the continental slope and borderland south of Point Sur.

The second ship study is by S. P. Tucker and involves the definition of the optical properties of the waters in a band 30 nautical miles wide and 200 miles long off the California coast between Point Reyes and Point Buchon. The objective is to understand temporal and spatial variations in the optical properties in terms of the ordinary oceanographic observables.

Also, from the ACANIA, E. C. Haderlie carries out a survey of the biology of stone and wood boring organisms in the deeper waters of the Monterey Bay. His purpose is to determine the identity and the vertical and horizontal distribution of these borers as well as their growth rates, settlement times, and destructive effects.

In Chemical Oceanography E. D. Traganza is using the ACANIA off the coast of California in a study of chemical mesoscale associated with ocean fronts. Cruises are coordinated with satellite imagery obtained from the National Environmental Satellite Service. These measurements may be used to link chemical, biological and acoustic properties of ocean fronts and eddies in the eastern boundary region of the North Pacific Ocean. The sponsor is ONR Code 480.

Two other faculty members, namely R. G. Paquette and R. H. Bourke, make use of U.S. Coast Guard ice breakers to observe and analyze ocean thermal finestructure near the ice margin in the Chukchi Sea. These studies have acoustical applications. Six mid-summer cruises have been conducted, the last in 1978. The sponsor is the Arctic Submarine Laboratory.

Physical factors affecting sound propagation in the ocean are being studied by Professors Denner and Thornton. Spatial and temporal variability of upper ocean physical parameters are being measured. This is an NPS Foundation program.

COASTAL STUDIES

The first of these studies, conducted under the direction of E. B. Thornton, concerns the kinematics of breaking waves in the surf zone. It is based on measurements of water particle motion and will provide increased understanding of the energy distribution within the surf zone and associated phenomena. Measurements are being made in Monterey and at La Jolla as part of a national field measurement program (ONR).

W. C. Thompson is completing a statistical investigation of wave-group properties of ocean waves. Findings to date suggest that as the wave-group period approaches the spectral peak period of the wave record all other wave-group properties assume maximum values (wave-group duration, number of waves, ratio of group energy to record energy, etc.). This study has applications to ship motions in ocean waves, wave damage of offshore structures and rubble-type breakwaters, and seiching in harbors. Entitled "Monterey Bay Ocean Wave Study", the project is funded by the State of California in a cooperative effort with the Army Corps of Engineers. The study includes the deployment and maintenance of a Datawell wave buoy in relatively deep water off Monterey Bay. Dr. Thompson is also studying the problem of defining vertical datum planes in estuaries in the zone of transition where the water level reflects both the harmonic tidal regime of the open coast and the irregular river stage regime of the navigable river. These reference planes are used in practice for both depth charting and for property boundary determination. This applied study is sponsored by the National Ocean Survey of NOAA.

Dr. Haderlie has been using concrete wharf pilings and other structures on the coast in identifying organisms responsible for deterioration of engineering materials placed in the sea and in determining the general biology and destructive effects of these organisms.

Another study involving coastal field work is a program in marine fog being conducted by D. F. Leipper and G. H. Jung and R. Renard of Meteorology. This project involves relationships between measurements from the R/V ACANIA and regularly obtained meteorological observations at shore stations. The project also undertakes analyses of data gathered at sea by other means such as through aircraft, satellites and commercial and weather ships. It is now extended to open ocean investigations in the Gulf of Alaska. An extensive coordinated survey was conducted off Southern California in May 1978. (CEWCOM '78) (NEPRF program)

DEEP OCEAN DATA ANALYSIS AND PREDICTION

This study (modeling upper ocean thermal structure) is conducted by R. W. Garwood in conjunction with R. L. Elsberry and R. L. Haney of the Department of Meteorology. Their investigations of the response of the ocean surface turbulent boundary layer to atmospheric forcing have led to the development of models that can be used to compute upper ocean thermal structure changes if the atmospheric conditions are known. The success of these models under test conditions has led to an applied research program in which the models shall be used to aid in the analysis of the upper ocean thermal structure, especially in those regions of the ocean that lack frequent observations. A spin-off of this research is an effort to couple an oceanic general circulation model to an oceanic boundary layer model.

R. H. Bourke, with Dr. G. E. Dorman of San Diego State University, has just completed a study to obtain new estimates of oceanic rainfall over the Pacific Ocean based on a correlation of rainfall amount with the present weather observation as recorded by ships at sea. Analysis of Atlantic Ocean data is in progress. A comparison between evaporation and precipitation rates over the oceans will be conducted in the future.

Ocean observations taken along latitude sections in the Atlantic Ocean during IGY have been used by G. H. Jung as the basis for new geostrophic calculations of mass, salt and heat transported in that ocean. Values of heat carried by these large scale circulations in the North Atlantic are being compared to values transported by various smaller scale phenomena there; South Atlantic Ocean computations are also completed as well as data for two South Pacific Ocean sections. One North Pacific section is being readied for computation. All ocean transports are being compared to associated climatic anomalies of the data period.

SPECIAL STUDIES

Under the ONR Chair in Arctic Marine Science Professor Denner has been conducting research into Navy related Arctic problems including ice modelling, ambient noise, microstructure in water temperature and salinity, and weapon performance. Dr. W. Weeks, the current occupant of this Chair, is working on the crystallography of arctic ice and is organizing a workshop on problems of the Seasonal Sea-Ice Zone to be held in February at NPS.

J. J. von Schwind has completed and contracted with Prentice Hall volume one of treatise covering the geophysical fluid dynamics of the ocean. This treatise will cover the fundamentals, ocean circulation theories and models, elementary and advanced wave theory, internal waves and tides, and advanced topics.

Relations between environmental parameters of atmosphere or ocean and long range low frequency sound propagation in the North Pacific Ocean are described by research underway by W. W. Denner and G. H. Jung. Particular problems with applications of interest to Commander, Oceanographic Systems Pacific are being investigated.

Title: Earth Physics Program Requirements

Investigator: Robert S. Andrews, Associate Professor
of Oceanography

Sponsor: Office of Naval Research

Objective: Provide assistance to the Earth Physics Program (Code 463) of the Office of Naval Research in the definition, planning, and execution of research in earth physics including policy formulation, budget preparation, and justification, and coordination of research activities within the Department of Defense and other governmental funding agencies. Work accomplished on-site at ONR Headquarters, Arlington, Virginia while investigator is on leave-of-absence from NPS.

Summary: Investigator has been performing his duties at ONR since May 1977 and is funded to remain on this assignment through September 1979. On 24 March 1978, investigator was appointed Director (Acting) of the Earth Physics Program by the Chief of Naval Research.

Publications: R. S. Andrews and J. G. Heacock, "Earth Physics Program", in Office of Naval Research Terrestrial Sciences Sub-element Review Minutes, 10 April 1978.

Title: Acoustic Variability and Air-Sea Transfer

Investigators: W. W. Denner, Associate Professor of Oceanography
K. L. Davidson, Associate Professor of Meteorology
T. P. Stanton, Adjunct Professor of Oceanography

Sponsor: Foundation Research Program (6.2)

Objectives: The following are the objectives of AVAST:

- (1) To measure simultaneously, high frequency sound propagation variability air-sea transfer, and vertical temperature microstructure in the upper layer of the ocean.
- (2) Determine the relationship between the measured propagation variability and air-sea transfer.
- (3) Determine the refractive index "Structural characteristics" of turbulence C_n from the acoustic measurement of the measured mean square amplitude fluctuation.
- (4) Provide a comprehensive set of data for future development and testing of mixed layer models.
- (5) Develop a model of the mixed layer that can be used to predict high frequency acoustic wave propagation variability.

Summary: During the past year the equipment and techniques necessary to meet the above measurement objectives have been developed. The telemetry system has been ordered from a commercial vender. Several "field test" cruises have been conducted and problem areas delineated. The temperature microstructure profiling system has been successfully deployed at sea and a Masters Thesis giving the results is in preparation. A full scale field experiment is planned for the summer of 1979.

Publications:

Denner, W. W., B. F. Rickard and
A. C. Kibblewhite, "Temperature
Microstructure and Ultrasonic
Propagation in the Sea". Accepted
by Deep Sea Research for publication
in 1979.

Title: Acoustic Variability and Air-Sea Exchange

Principal Investigators: W. W. Denner, Associate Professor of Oceanography, K. L. Davidson, Associate Professor of Meteorology, T. M. Houlihan, Associate Professor of Mechanical Engineering, J. V. Sanders, Associate Professor of Physics and Chemistry and E. B. Thornton, Associate Professor of Oceanography

Associate Investigator: T. P. Stanton, Adjunct Professor of Oceanography

Sponsor: Foundation Research Program (6.2)

Objective: To better understand the relationship between air-sea interaction and the variability of underwater sound propagating through the upper layers of the ocean.

Summary: Preliminary designs for both the acoustic propagation measurement system and temperature microstructure profiler were fabricated and tested during three sea trials. Redeployable free-floating acoustic receiver buoys were designed and constructed. A two channel, computer-controlled acoustic preprocessing unit was prototyped for use in preliminary sea-trials. Software was developed for the HP 9825/3052 data acquisition system to process and store acoustic propagation data and atmospheric environmental information. A prototype variable-buoyancy, 'Yo-Yo' profiler was developed. Two sensor packages and ship-board electronics were designed, constructed and tested. The first was a depth sensor and single thermistor, and the second an eight-channel computer-controlled depth sensor and horizontal thermistor array. Three separate sea-trials of the free-floating acoustic propagation system were undertaken at San Nicholas Island (in conjunction with CEWCOM 78) and in Monterey Bay during August and September 1978. Following the first trial, a remote-controlled free-floating acoustic transmitter buoy was developed. During the September sea-trials the temperature microstructure profiler was used to obtain measurements which formed the basis for a Master's thesis for a participating NPS student.

Conference**Presentations:**

W. W. Denner, E. B. Thornton, T. P. Stanton, "Acoustic Variability and Air Sea Transfer", presented at MORS Conference, Naval War College, Newport, R.I., December 5, 1978.

Publications:

W. W. Denner, B. F. Rickard and A. C. Kibblewhite, "A Temperature Microstructure Probe", Marine Sciences Communications, 3(1) pp 61-91, 1977.

W. W. Denner, B. F. Rickard and A. C. Kibblewhite, "A Study of Temperature Microstructure in Coastal Waters", submitted to Deep Sea Research.

W. W. Denner, B. F. Rickard and A. C. Kibblewhite, "Temperature Microstructure and Its Influence Upon the Propagation of Ultrasonic Sound in the Sea", submitted to Deep Sea Research.

Thesis Directed:

C. Christiansen, "Temperature Microstructure Profiles in Monterey Bay", Master's Thesis, December 1978.

Title: Sonic Mixed Layer Experiment

Investigator: W. W. Denner, Associate Professor of Oceanography

Sponsor: Naval Ocean Systems Center

Objective: To study the impact of the mixed layer and change in the mixed layer depth on long range, low frequency sound propagation from a source within or below the mixed layer to a bottom mounted receiver.

Summary: In connection with the ONR Mixed Layer Experiment (MILE) conducted in August and September 1977 at Ocean Station PAPA (50°N, 145°W), Sound Underwater signals (MK61) were deployed from P-3 aircraft in a pattern around station PAPA. The sound waves from these signals were recorded at several locations in the Northeast Pacific. MILE was a multiship, U.S. and Canadian program, to study the response of the mixed layer of the ocean to the passage of a storm.

Received signals from flights before, during and after the passage of a storm are being analyzed to determine the effect of mixed layer changes on the propagation.

This is a continuing project in a co-operative program between NOSC and NPS.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM. (U)

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Title: Arctic Chair in Marine Science

Investigator: W. W. Denner, Associate Professor
of Oceanography

Sponsor: Office of Naval Research

Objective: The ONR Chair in Arctic Marine Science was established in January 1977. The purpose of the Chair is to:

- (1) Foster an interest in the Arctic among Naval officers
- (2) "Spotlight" the Navy's growing interest in the Arctic
- (3) Conduct research into problems in the Arctic that are of interest to the Navy
- (4) Translate the growing basic research results into operational Navy Products.

Summary: The following is a list of accomplishments under the Chair since its establishment:

1. A series of seminars have been sponsored. The speakers were experts in various areas of Arctic science of interest to the Navy.
2. The first Navy workshop on the Numerical Prediction of Sea Ice Conditions was held 19-21 June 1978 in Monterey, California.
3. A numerical sea ice dynamics model has been programmed on the FNWC computer and simulations of the Arctic ice pack have been made using FNWC atmospheric fields.
4. FNWC atmospheric analysis fields (surface pressure and temperature) have been evaluated in the Arctic and found to need further development.
5. The need for more meteorological observations from the Arctic has been established. Based on this result a program of satellite telemetry buoys has been justified and funded.
6. Ambient noise models are being developed for the Arctic.

Title: Oceanographic Studies in Support of COMOCEANSYSPAC

Investigators: Warren W. Denner, Associate Professor of Oceanography and Glenn H. Jung, Professor of Oceanography

Sponsor: Naval Ocean Systems Center, Code 8407

Objective: Relate observed environmental parameters to surface and subsurface oceanic features that affect long range low frequency sound transmission in the North Pacific Ocean.

Summary: Long range acoustic propagation measurements of September 1977 made during MILE were analyzed with respect to changing environmental conditions in space and time. Data from before, during, and after the passage of a moderate storm were analyzed and compared to explore the effect of the storm on sound propagation conditions. Differences were found in both the pressure time histories and frequency spectra which are believed due to variations in the sea surface roughness. Other spectral differences were attributed to changes in the amount of energy coupling into different paths due to changes in the sound-speed profile caused by the storm. Attenuation coefficients were calculated which are in excellent agreement with results in Kibblewhite et al, in 1977. Small differences were attributed to the effects of a seasonal subsurface sound channel.

7. The Navy needs for Arctic science is being reviewed and will be reported to the sponsor.
8. Bathymetric data collected by U.S. nuclear submarines has been analyzed and compared to available charts. Existing charts are found to be in substantial error.
9. A model simulating the performance of the MK48 torpedo under the ice has been developed and will be validated against available data.

The following scientists have occupied the Chair:

January 1, 1977 - September 30, 1977
Dr. Warren W. Denner, past Director of the Naval Arctic Research Laboratory

October 1, 1977 - September 30, 1978
Dr. Allen Beal, Senior Scientist, Arctic Submarine Laboratory, NOSC, San Diego

October 1, 1978 - September 30, 1979
Dr. Wilford Weeks, Senior Research Scientist, Snow and Ice Branch, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire

Publications:

W. W. Denner and L. D. Ashim, "The Operational Determination of Wind Stress on the Arctic Ice Pack", Proceedings of a Symposium on Sea Ice Processes and Models, 6-9 September 1977, Seattle, Washington, Vol. 2, pp 108-119

- Title:** Biological Contributions to Shoreline Erosion in Santa Cruz, California
- Investigators:** Eugene C. Haderlie, Professor of Oceanography and Gerald Clark, Lieutenant, U. S. Navy
- Sponsor:** Foundation Research Program (6.1)
- Objective:** To investigate the influence of rock boring bivalves on rates of erosion of the sedimentary rock forming the shoreline at Santa Cruz, California.
- Summary:** This investigation was carried out during the spring and summer of 1978. Extensive intertidal work was done as well as shallow water diving and dredging using R/V ACANIA. The rock boring bivalves have been identified, the ranges mapped, and destructive influence evaluated.
- Publications:** E. C. Haderlie, "Recent Rock Boring Marine Bivalves from Monterey Bay, California", submitted for publication in the Proceedings of the Dall Symposium, Geological Society of America, to be published in Spring 1979.
- Thesis Directed:** G. Clark, "Rock Boring Bivalves and Associated Fauna and Flora of the Intertidal Terrace at Santa Cruz, California", Master's Thesis, September 1978.

- Title:** Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters Off the Central California Coast
- Investigator:** Eugene C. Haderlie, Professor of Oceanography
- Sponsor:** Ocean Sciences and Technology Division, ONR, NORDA/NSTL, Bay St. Louis, Missouri (LCDR R. Tipper)
- Objectives:** To determine the distribution of stone and wood borers in the deeper water of Monterey Bay and offshore, and to determine rates of destruction of wood and various kinds of stone in the sea.
- Summary:** Extensive dredging using R/V ACANIA has been carried out to determine the distribution and density of stone borers in the natural rock outcrops in Monterey Bay. Experimental arrays containing wood and stone samples have been placed at various depths and recovered at regular intervals for analysis. So far, 20 species of boring animals have been found, and rates of penetration into hard substrates measured.
- Conference Presentations:** E. C. Haderlie, "Recent Marine Rock Boring Bivalves from Monterey Bay, California", to be presented at the Dall Symposium, Geological Society of America in April 1979, also submitted for publication in the Proceedings of the Dall Symposium, Geological Society of America.
- Publications:** Haderlie, E. C., "1979 Range extension for Penitella fitchi Turner, 1955 (Bivalvia: Pholadidae)," submitted to Veliger (in press).
- Haderlie, E. C., "Stone Boring Marine Bivalves of the Monterey Submarine Canyon," submitted to the Malacozoological Society of California for publication in their journal.

Title: Biodeterioration Studies in Monterey Harbor

Investigator: Eugene C. Haderlie, Professor of Oceanography

Sponsor: Naval Facilities Engineering Command Washington, D.C. (Mr. H. Lamb)

Objective: To continue and conclude long term studies in the harbor at Monterey on the biodeterioration of engineering material due to the activities of marine organisms.

Summary: This project has involved the study of the life cycles and destructive activities of a number of marine organisms in the harbor. The results have been identification of the species involved, the time of settlement, rates of growth, and extent of damage to a number of engineering materials.

Publications: Haderlie, E.C. and W. Donat, "Wharf Piling Fauna and Flora in Monterey Harbor, California". The Veliger, 21: 45-69. (July 1978)

Title: Low Wavenumber Ocean Energy Transport

Investigator: Glenn H. Jung, Professor of Oceanography

Sponsor: Office of Naval Research, Code 481

Objective: With attenuation concentrated on the very low wavenumber region of the ocean temperature turbulent spectrum, the role played by large-scale ocean circulations will be indicated as they function as possible energy sources for remaining circulation scales of this spectrum.

Summary: Seven latitude sections across the North Atlantic Ocean have been processed by computer program for mass, salt, and heat transported by ocean currents during the IGY. Transports within different watermasses are summed. Circulation patterns for the upper, intermediate and deep/bottom ocean layers have been developed. Also, four latitude sections have been processed in a similar way within the South Atlantic Ocean, with a computer program modified to include calculations for near bottom data-free areas and to summarize by watermasses (both previously computed by hand). A manuscript in preparation will summarize project results and compare them with values of smaller scale eddy transports estimated by others.

Conference Presentations:

G. H. Jung, "Ocean Energy Transport Anomalies During the Sunspot Maximum of the IGY (Autumn 1977)", presented at American Geophysical Union Fall Meeting, San Francisco, California, 5-9 December 1977.

G. H. Jung, "Are the Oceans a Necessary Link Between Solar Variability and Earth's Climatic Anomalies?", presented at Chapman Solar Terrestrial Coupling Conference (American Geophysical Union), Yosemite, California, 8-11 February 1978.

Theses Directed:

Timothy L. Baker, "Mass, Salt, and Heat Transport Across Seven Latitude Circles in the North Atlantic Ocean: A Description of the General Circulation Based on Geostrophic Calculations from International Geophysical Year and Adjacent Data", Master's Thesis, June 1978.

J. Robert Mason, "Mass, Salt and Heat Transport Across Four Latitude Circles in the South Atlantic Ocean", Master's Thesis, December 1978.

Title: Marine Fog Forecasting

Investigators: Dale F. Leipper and Glenn H. Jung, Professors of Oceanography, Robert J. Renard, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: To improve the analysis and forecasting of marine fog over the open ocean and coastal areas.

Summary: Observations of fog at sea will be obtained from OSV "P" and the NPS oceanographic research vessel ACANIA. These will be analyzed and related to synoptic parameters representing the atmosphere and ocean. An attempt will be made to quantify visual and infrared satellite imagery to identify marine fog over the open ocean and coastal areas. The data will be arranged in a form suitable for computer processing. Development will continue on a statistical, numerical approach to analyze and forecast marine fog using model output parameters from Fleet Numerical Weather Central, weather satellite imagery, climatology and conventional data. Improvement of coastal fog forecasting will be sought using the Leipper conceptual model and forecasting indices.

Analysis of data collected during CEWCOMs 1976 and 1978 continues and a draft is completed on the value of previously described fog forecasting indices based upon the regional data collected in those experiments. GOES WEST satellite data for July 1978 are being acquired at the Space Science and Engineering Center at the University of Wisconsin, Madison, in preparation for future development of the statistical scheme to uniquely identify fog by remote sensing. A step-wise selection multiple linear regression approach is under development from summer 1976 North Pacific data, using FNWC model output parameters and climatology to probabilistically specify marine fog. The scheme

shows skill relative to the current FNWC products.

Publications:

D. A. Backes, "Santa Ana Associated Offshore Fog: Forecasting with a Sequential Model", Technical Report, NPS 68Lr77091, September 1977.

D. G. Leipper, "CEWCOM-78, A Plan (Cooperative Experiment in West Coast Oceanography and Meteorology-1978)", Project Report, NPS 68-78-003PR, March 1978.

D. F. Leipper, "NAVAIR Marine Fog Project - 1973-1977", Naval Postgraduate School Internal Technical Report, 30 January 1978.

Title: Studies of Finestructure in the
Marginal Sea-Ice Zone--MIZPAC 77-78

Investigators: R. G. Paquette, Professor of
Oceanography
R. H. Bourke, Associate Professor
of Oceanography

Sponsor: Arctic Submarine Laboratory
Naval Ocean Systems Center
Code 87, Bldg 371
San Diego, CA 92152

Objective: Reduce and analyze data from the 1977
MIZPAC cruise to the Marginal Sea Ice
Zone (MIZ) of the Chukchi Sea. Prepare
for and carry out field measurements
in MIZPAC 78. This is part of a
continuing program.

Summary: Oceanographic measurements have been
carried out during midsummer in the
vicinity of the MIZ of the Chukchi
Sea since 1971. These studies are in
support of submarine operations under
ice. Results from the 1977 cruise
indicate an apparent correlation
between the ice melt-back pattern,
surface currents, and the existence of
fronts and temperature finestructure.
This correlation appears valid for
data from previous MIZPAC cruises. The
MIZPAC 78 data is being analyzed for
further support of this correlation.
Historical data from the Bering Sea,
gathered during spring and early summer,
are being examined for evidence of
finestructure formation. No cruise
to the MIZPAC area is planned for
summer 1979.

Publications: Paquette, Robert G., and R. H. Bourke,
"Temperature Finestructure Near the
Sea-Ice Margin of the Chukchi Sea"
submitted to Journal of Geophysical
Research.

Robert G. Paquette and R. H. Bourke,
"The Oceanographic Cruise of the
USCGC BURTON ISLAND to the Marginal
Sea-Ice Zone of the Chukchi Sea-
MIZPAC 77", Technical Report, NPS 68-
78-001, February 1978.

Robert G. Paquette, R. H. Bourke, and
Gordon P. Graham, "Finestructure,
Fronts and Currents in the Pacific
Marginal Sea-Ice Zone", Technical Re-
port, NPS 68-78-006, June 1978.

Conference
Presentations:

Classified

Theses Directed:

Gordon P. Graham, "Finestructure,
Fronts and Currents in the Pacific
Marginal Sea-Ice Zone", Master's
Thesis, June 1978.

Walter R. Lohrmann, "Oceanic Fronts
Near the Ice in the Bering Sea",
Master's Thesis, expected in March 1979.

Title: Vertical Datum Planes in the Ocean/
River Transition Zone

Investigator: Warren C. Thompson, Professor of
Oceanography

Sponsor: National Ocean Survey, NOAA

Objective: To define suitable vertical datum
planes in the transition zone of
estuaries where the water level
is composed of both periodic tidal
oscillations and irregular river-
stage variations.

Summary: In the ocean/river transition zone
vertical reference planes are
essential for depth charting and
for the determination of waterfront
property boundaries. In this
investigation, time-series water-level
measurements available for a selected
gaging station in the transition zone
of a navigable river (Sacramento on
the Sacramento River) will be separated
into a tidal component and a river-
stage component. Each component
will be statistically analyzed for
datum planes, and the relationships
between the planes examined. Stability
and continuity of reference planes
through the transition zone will be
of principal concern. This study
is continued into FY1979.

Publications: (A report is in preparation).

Title: Undersea Acoustic Surveillance of Offshore Oil and Gas Platforms

Investigator: Warren C. Thompson, Professor of Oceanography

Sponsor: Office of Naval Research, Naval Analysis Program (Code 431)

Objective: To evaluate the limitations imposed by the marine environment on underwater acoustical detection of unfriendly surface and subsurface targets in the vicinity of an offshore platform.

Summary: The protection of offshore oil and gas platforms through acoustical detection and classification of intruding swimmers and delivery vehicles was examined under a wide range of environmental conditions. The problem involved selection of a surveillance system from various possible designs. Three state-of-the-art ultrasonic sonars (one pulsed and two doppler detectors) were specified. Field data combined with the active sonar equation were used to quantify the effects of 69 environmental parameters on detection ranges of these sonars. Excessive reverberation from the sea surface and sea floor was determined to be the primary limitation on detection by the pulsed sonar, whereas, absorption is the major restriction on doppler detection ranges. This surveillance problem is one of strategic national concern. Details of results obtained are classified. This study has been completed.

Title: Monterey Bay Ocean Wave Study

Investigator: Warren C. Thompson, Professor of Oceanography

Sponsor: California Department of Navigation and Ocean Development in cooperation with the Army Corps of Engineers

Objectives: (1) To establish and maintain an ocean wave sensor off Monterey Bay for the purpose of obtaining wave measurements in relatively deep water, and (2) to investigate the properties and occurrence of wave groups from the analysis of wave records.

Summary: A Datawell wave buoy was installed in June 1978 in relatively deep water off Monterey for the purpose of providing data for the study of ocean wave groups, for use by the State of California in its Coastal Engineering Data Network, and for use by the Army Corps of Engineers in its study of Santa Cruz Harbor. The sensor has operated continuously since its installation. The wave-group study is examining the statistical properties of wave groups and their relationship to the properties of the wave record. Findings to date suggest that as the wave-group period approaches the spectral peak period of the record all other wave-group properties assume maximum values (i.e. wave-group duration, number of waves in a group, and ratio of group energy to record energy). This study has applications to ship motions, wave damage of offshore structures and rubble breakwaters, and seiching in harbors. This study is continued into FY 79.

Thesis Directed: D. G. Sedivy, W. C. Thompson, "Ocean Wave Group Analysis", Master's Thesis, September 1978, also issued as Technical Report, NPS68SeTh78091, September 1978.

Title: Field Measurements of Surf Zone Energetics

Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: National Oceanic and Atmospheric Administration, National Sea Grant Program

Objective: The overall objective of the Nearshore Sediment Transport Study (NSTS) is to develop an engineering formula to predict sediment transport. For the model to have sufficiently general applicability, it is necessary to understand the physics of granular-fluids and the forcing functions causing the sediment transport. The specific objective of this proposal is to make field measurements (under a variety of conditions) of waves, and turbulent and wave-induced velocities within the surf zone. These measurements are an essential part of the effort to characterize the forcing function for sediment transport processes as a function of incident wave and beach parameters.

Summary: Littoral sand transport is a function of the turbulent and wave energy within the surf zone and of the longshore currents generated by the incident waves. Turbulence is derived from the coherent wave energy as part of the dissipation process associated with wave breaking. The combination of wave and turbulent velocities act as a stirring mechanism putting sediment into motion. Longshore currents are generated by the coherent wave energy and act as a transporting agent for the sand along the shore. The proposed measurement program is designed to measure the wave related forcing functions for sediment transport. Quantities to be measured are sea surface elevation and fluid velocities. The swash measurements will determine the super-elevation of the mean shoreline above still water level (set-up) and the time history of the run-up. This proposal is intended as an intermediate stage of a multi-year effort aimed at

understanding the aspects of surf zone fluid mechanics which are relevant to sediment transport.

A major field experiment was conducted for a period of one month from 24 October to 24 November 1978 at Torrey Pines, California. The experiment involved the simultaneous measurement of up to 90 channels of wave and current velocities.

Title: Kinematics of Breaking Waves in the Surf Zone

Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: Office of Naval Research, Geography Branch, Code 462, Arlington, VA (6.1)

Objective: Basic studies are being made on the kinematics of breaking waves within the surf zone in the field. The specific objectives of the proposed research are: (1) determine breaking criterion as a function of depth, beach slope and wave frequency and (2) determine the transformation of waves across the surf zone due to energy conversion and dissipation in the breaking process.

Summary: This research is being accomplished at various field sites for the conditions of spilling, plunging and collapsing breaking waves. Waves and orthogonal water particle velocities are measured at a large number of locations within the surf zone. The spectral characteristics and probability density functions for breaking waves and water particle velocities are calculated.

Measurements have been made on both sandy beaches and coral reefs. The dynamics of wave transformation are similar and are shown to be highly nonlinear. Energy is transferred from the primary spectral wave frequency to higher and lower frequencies in the shoaling and subsequent breaking process. The energy transferred to higher frequencies results in secondary waves at harmonic frequencies and a cascade of energy in a saturation range above the harmonic region. Separation of wave-induced and turbulent kinetic energies shows that most of the kinetic energy is wave-induced even under breaking waves. Joint pdf's of height and periods of breaking waves show high correlation (>0.7) and bimodality due to secondary waves.

Publications:

E. B. Thornton and W. D. Morris, "Suspended Sediments Measured in the Surf Zone", Proceedings of the Coastal Sediments 77 Conference, ASCE, 1977, pp 655-668.

E. B. Thornton, "Energetics of Breaking Waves Within the Surf Zone", accepted for publication in Journal of Geophysical Research, July 1978.

E. B. Thornton and G. Schaeffer, "Probability Functions of Breaking Waves", Proceedings of the 16th International Conference on Coastal Engineering, September 1978.

R. T. Guza and E. B. Thornton, "Long-shore Current Variability", Proceedings of 16th International Conference on Coastal Engineering, September 1978.

Title: Biochemical Modelling of Marine Ecosystems and Acoustic Prediction

Investigator: Eugene D. Traganza, Associate Professor of Oceanography

Sponsor: Foundation Research Program (6.1)

Objective: The initial objective of this study was based on the hypothesis that a firm knowledge of the number of zooplankton "patches" in the ocean is useful in predictive models of sound scattering.

Summary: An evaluation of this hypothesis has been severely limited by the inadequacies in assessing zooplankton biomasses, their trophic levels and variability in time and space; consequently, the approach has been (1) test the hypothesis with existing data (2) consider the precision of zooplankton collecting devices (3) determine the potential of making rapid, accurate, biochemical measurements that reflect zooplankton biomass, and (4) compare biochemically assayed biomasses with zooplankton predicted by models of the Monterey upwelling region.

Considerable progress has been made in all of these objectives as indicated by four published articles (one classified in J. Underwater Acoustics), 2 pending publications, and six Master's theses over the past five years. Significant in this research sequence was the development of a carbon method of measuring the total biomass of "net zooplankton" (60 reprint requests since publication) and a further determination that the compound adenosine triphosphate (ATP) may be useful in distinguishing the live/dead ratio of zooplankton in a given sample (80 reprint requests to date). At present it is not conclusive to compare C/ATP ratios reported by different investigators because ATP methods are not intercalibrated, and there are critical effects caused by capture stress and sample processing. None the less, the research is encouraging.

Publications:

E. D. Traganza, "Equilibrium Calculations as Evidence to the "Normal" Range of C/ATP Ratios in Marine Zooplankton", submitted to Limnology and Oceanography, 1978.

E. D. Traganza, J. W. Swinnerton and C. H. Cheek, "Methane Supersaturation and ATP-Zooplankton "Blooms" in Near-Surface Waters of the Western Mediterranean and the Subtropical North Atlantic Ocean", submitted to Deep Sea Research, 1978.

E. D. Traganza and K. J. Graham, "Carbon/Adenosine Triphosphate Ratios in Marine Zooplankton", Deep Sea Research, 24, 1977, pp 1187-1193.

Title: Chemical Mesoscale and ATP-Biomass Correlated with Satellite Imagery of Ocean Fronts

Investigator: Eugene D. Traganza, Associate Professor of Chemical Oceanography

Sponsor: Office of Naval Research, Code 480

Objective: The initial objective of this study was based on the hypothesis that chemical mesoscale will reveal fundamental mechanisms which control the marine ecosystem and the distribution of planktonic communities. This information should lead to the development of new ecosystem models and the models should be useful in predicting acoustic properties of biological origin.

Summary: Research cruises in the California Current region have been coordinated with satellite infrared imagery of the sea surface temperature provided by the National Environmental Satellite Services at Redwood City. At least five types of thermal mesoscale features have been targeted for study in what is colloquially referred to as the "Front Hunt" (1) Weak persistent linear fronts extending across the entire California current system (2) large anticyclonic eddies (3) strong wave-like meandering thermal fronts extending through the axis of the California Current (4) the outer edge front of the California Current and (5) sharp upwelling fronts originating in the coastal zone.

Significant in the first series of cruises is the chemical and biological characterization of a sharp thermal front associated with upwelling seaward of Point Sur Cal. Future plans include a north-south transect from Monterey Bay California to the Gulf of Tehuntepec, Mexico.

Title: Dynamics of the Oceans

Investigator: J. J. von Schwind, Associate Professor
of Oceanography

Sponsor: Naval Sea Systems Command
Mr. John Ropek

Objective: To prepare a detailed and systematic treatise covering the geophysical fluid dynamics of the oceans. When complete, the said treatise will include fundamental and advanced topics and be so structured and written as to be particularly useful to technical persons whose work involves the ocean environment but who may have little or no formal education in theoretical physical oceanography.

Summary: The treatise in its entirety will consist of four major parts: (1) Fundamentals of Geophysical Fluid Dynamics; (2) Ocean Circulation Theories and Models; (3) Elementary and Advanced Wave Theories, Internal Waves, Tides; and (4) Advanced Topics in the Fluid Dynamics of the Ocean. At the present time, the subject matter to be covered is found only in a wide variety of sources, ranging from textbooks and technical journals to personal unpublished notes. To date the first two sections have been completed and constitute Volume 1 of the treatise.

Publications: Copy of Volume 1 has been forwarded to sponsor excluding references and index. Volume 1 accepted for publication by Prentice-Hall.

- Title:** Study of the California Countercurrent Off Central California
- Investigators:** J. B. Wickham, Associate Professor of Oceanography and S. P. Tucker, Assistant Professor of Oceanography
- Sponsor:** Foundation Research Program (6.1)
- Objective:** Continuation of our monitoring of this current system, adding direct measurements made by an array of moored meters.
- Summary:** This is a field study with two parts: one involves continuous direct recording of currents with moored meters, the other the sensing of the physical structure of the water masses with shipborne vertical profilers (of temperature and salinity and pressure).
- Regarding the metering, we have worked on the practice of mooring and recovering meters, beginning with a single meter moored in shallow water to an array of nine meters on three moorings, one in water of depth greater than 1000 m. Two months' data from a six-meter array are now being processed.
- The vertical profiling, which is used to describe the water masses and to estimate by geostrophy the currents over a broad area surrounding our array, has continued routinely. We have completed six temperature sections (of 23 soundings each) and two STD (temperature, salinity, depth) sections. Drogues have been deployed for additional current estimates. Preliminary analysis of the profiles and drogue paths indicates "southern" water masses and northward flow along the continental slope in the region of our moored arrays.
- Thesis Directed:** Keith Coddington, "Observations of the California Countercurrent", Master's Thesis, to be completed June 1979.

Title: Three Dimensional Structure and Behavior of Mesoscale Ocean Features Associated with Their Remotely Sensed Surface Signature

Investigators: Jacob B. Wickham, Associate Professor of Oceanography and Stevens P. Tucker, Assistant Professor of Oceanography

Sponsor: National Aeronautics and Space Administration

Objective: Our objective is to observe the evolution and propagation of an ocean frontal system which may develop into a mesoscale eddy. We plan to use remotely sensed temperature fields to indicate the location of a suitable feature for study.

Summary: Our plan is to examine in situ features as described above, using a sequence of at least two ship borne instrumental surveys to show changes of structure. We shall use, in addition, data from a moored array of current, temperature and salinity sensors to monitor continuously the variations in fronts or eddies as they pass through the region covered by the array. A simple physical model suggests quite different propagation characteristics for mesoscale features, depending upon their relative vertical development - i.e., superficial features versus vertically developed ones. The project has not yet begun formally, but we have installed some elements of the array to be used with support from other sources. Data are being collected presently with that array.

Title: Satellite Ocean Surface Temperature Observations of Fronts and Eddies

Investigators: Jacob B. Wickham, Associate Professor of Oceanography
Stevens P. Tucker, Assistant Professor of Oceanography

Sponsor: Fleet Numerical Weather Central, Monterey, California

Objective: The study's objective is to compare satellite sensed regions of complex surface temperature structure (fronts and eddies) with surface and subsurface temperature structures observed by in situ measurements. A primary purpose of these comparisons is to show the extent to which remotely sensed surface temperature patterns are representative of the three-dimensional thermal structure which influences underwater sound transmission in surface ocean layers.

Summary: The comparisons are to be made of surface temperature patterns inferred from QEOS III satellite VHR infra red sensors with surface and subsurface temperature patterns obtained from XBT and STD (salinity, temperature, depth) profilers and other ship borne instruments launched from R/V ACANIA. Progress to this date has included only the collection and scanning of infra-red sensed sea surface temperature patterns in the area of our interest. A narrow plane of warm water, persisting for three weeks is a promising feature for in situ work.

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering has a diversity of research interest and talent, as is evidenced by a variety of projects. These projects are categorized as follows: (1) materials science, (2) heat transfer, (3) structures, vibrations, and solids, (4) hydrodynamics and fluid mechanics, (5) energy conversion, (6) laser technology, and (7) marine propulsion controls.

MATERIALS SCIENCE

The Naval Postgraduate School has a strong commitment to research in Materials Engineering and Metallurgy. During FY78, Professor J. Perkins began a leave of absence at the Office of Naval Research, London. Prior to his departure, Professor Perkins continued his work in several areas, including (1) materials development for ship silencing applications, (2) corrosion of sacrificial anode materials for cathodic protection of ship hulls, and (3) velocity effects on corrosion of structural materials in seawater.

Adjunct Professor D. Boone has initiated research into hot corrosion of super alloys for gas turbine application. This research specifically is focusing on the resistance to hot corrosion conferred by several different coating systems. The effect of Platinum additions to coatings on the hot corrosion resistance of coated turbine-blade materials is being examined.

Professor T. R. McNelley has continued his work on thermomechanical processing of Aluminum-Magnesium alloys containing up to 14% Mg. Such alloys have been processed by isothermal rolling to large strains at temperatures both above and below the solvus for the alloy, and additionally processed by cold working after isothermal hot or warm working. A recent result has been the attainment of a yield strength (0.2% offset) of 79 KSI, an ultimate tensile strength of 88 KSI, and 6% elongation to fracture in an Aluminum - 10% Mg alloy. Research on the terminal ballistic characteristics of thermomechanically processed Ultra High Carbon Steels has continued. Recent results demonstrate superior ballistic resistance for such steels when compared to Rolled Homogeneous Steel Armor using fragment simulating projectiles; an unusual feature is the absence of adiabatic shear band formation in these Ultra High Carbon Steels under conditions where conventional armor steels do exhibit shear banding. Work has also been initiated, in conjunction with Professor Boone, regarding the fatigue, fracture, and wear characteristics of these Ultra High Carbon Steels.

Heat transfer considerations in the design of engineering systems have taken on new importance with the need to design for energy efficiency. The department has continued to engage in a vigorous heat transfer research program.

Professor P. J. Marto has continued his investigation into improving the performance of main steam condensers. A test facility for investigating condensation on plain and enhanced tubes has been built, and eleven corrugated tubes have been tested to compare their heat transfer and pressure drop characteristics to a smooth tube. Corrected overall heat transfer coefficients were as much as twice those of the smooth tube, while cooling water pressure drop was as much as ten times the smooth tube. The data show that pitch or helix angle, as well as groove depth, are important variables in enhancing heat transfer.

Professor Marto has also continued his investigation of the heat transfer performance of rotating wickless heat pipes. Recent work with Professor Salinas has concentrated on examining the performance of internally finned condenser sections and on comparing experimental results to an existing finite element analysis. A linear triangular finite element formulation has been used to solve the steady state two-dimensional conduction heat transfer equation in the condenser wall.

Professors M. D. Kelleher and R. P. Shreeve of the Aeronautics Department have recently initiated an investigation in the heat transfer and fluid mechanics of turbomachinery blades in a rectilinear cascade. Verification of the flow conditions in the cascade is presently under way.

Professor Kelleher has continued his investigation of heat transfer in curved ducts. An experimental study of natural convection in thin horizontal liquid layers is also being conducted.

Under the leadership of Professor A. E. Fuhs, an interdisciplinary research team has been conducting heat transfer measurements using towed, instrumented icebergs, about the size of an automobile. Temperature measurements have been made in the seawater boundary layer, as well as in the ice itself. In a joint research project with Dr. Owen Griffin of the Naval Research Laboratory, a computer code has been developed to predict the trends which have been observed experimentally. Excellent agreement has been obtained between experimental results and the computer code.

STRUCTURES, VIBRATIONS, AND SOLIDS

Professor A. P. Boresi of the University of Illinois, this year's occupant of the NAVSEA Research Chair, is studying the dynamics of elastic systems containing rigid limit stops, vibration dampers, and other devices, with the intention of optimizing

gun barrel restraints for maximum accuracy. He is continuing his work on dynamics of hyperboloidal shell cooling towers under earthquake excitation. He is also developing computationally efficient finite element models for reinforced axisymmetric shells and is studying the behavior of cylinder-cone structures having intermediate continuity at the shell junction.

Professor J. E. Brock has continued work on numerical inversion of Laplace transforms and on elastic lateral buckling of nonuniform beams. He has completed a study of the use of hand-held programmable calculators in Mechanical Engineering education; ten of the programs therein described are in the above subject areas. He is also engaged in several studies for the Naval Undersea Warfare Engineering Station, Keyport, WA.

Professor Gilles Cantin has continued development of three dimensional methods for stress and strain analysis by the finite element method. He has completed a study on the Loubignac iteration scheme for improvement of surface stress predictions in the finite element method. He is currently studying some aspects of FORTRAN programming for scientific non-numerical applications. This includes having adapted the Wilson CAL program for fully interactive use on the NPS IBM/360 system.

Professor A. E. Fuhs has been investigating the vibrational frequencies and mode shapes of plates with flows or cracks, using holographic interferometry. Results show that a minor crack decreases vibrational frequency and causes gross changes in displacement. The aim of the research is to develop new methods for nondestructive testing (NDT). Further, the change in characteristics may provide a new method for kill assessment.

Professor R. E. Newton has continued to study applications of the finite element method to underwater shock problems. Efforts have been concentrated on the effects of cavitation and the resulting nonlinear mathematical models. Two formulations have been shown to give good results in one-dimensional problems. The investigation is currently concentrated on the development of a code to handle two-dimensional problems of shock induced cavitation.

Professor D. Salinas has been active in the analytical investigation of a laminate composite plate subjected to a severe thermal environment. The study utilizes computer programs for the thermo-mechanical response of the system.

HYDRODYNAMICS AND FLUID MECHANICS

Hydrodynamics and fluid mechanics are a vital technology for the Navy. A strong research program has been developed in support of Navy needs.

Professor Sarpkaya has been in charge of a number of basic, as well as applied, research programs. He continued his investigation into the understanding of the vortex breakdown phenomenon

over delta wings with the sponsorship of the Naval Air Systems Command. He continued to work on the cable strumming problems with the cooperation of the Naval Construction Battalion Center. The purpose of this investigation is to predict the conditions under which strumming occurs and to devise methods to minimize the consequences of strumming. Professor Sarpkaya also continued his work on time-dependent flow about bluff bodies. For this purpose, he built a large U-shaped tunnel in which periodic oscillations are created to simulate the wave and current action on ocean structures. The results of this investigation have received world-wide attention and were incorporated into design codes both in the States and abroad. Related to this investigation and of current interest are the hydroelastic oscillations of multiple-tube risers, pipelines, and ocean platforms. These projects are currently being investigated through the sponsorship of the National Science Foundation.

Professor Sarpkaya built a vertical water tunnel to investigate the impulsively started uniform flow about cylinders and other bodies for the purpose of exploring the relationship between this type of flow and the flow about a missile at high angles of attack. The existence of the so-called "impulsive flow" analogy has been known for quite some time, but data were lacking to substantiate the validity of the analogy. Parallel to these experimental investigations, an extensive computer study has been undertaken to study the separated flow about bluff bodies through the use of the discrete vortex model. The results of this investigation have formed the basis of a recent Ph.D. degree. Professor Sarpkaya has devoted considerable attention to the flow phenomena resulting from LOCA (Loss of Coolant Accident) in Boiling Water Nuclear Reactors. Specifically, the evolution of the jet in the downcomers, pool swell, and wave slamming on submerged structures in the suppression pool have been investigated. These results have been incorporated into the design regulations of the Nuclear Regulatory Commission.

The research initiated by Professor P. F. Pucci on the subject of optimized ship exhaust eductor has been continued. The purpose of this investigation is to assist NSRDC-Annapolis in the design of exhaust gas stack eductors for shipboard gas turbine propulsion plants. The program involves the design, construction, and testing of scale models, and the verification of analytical predictions. The results of the first series of tests have been most encouraging.

Professor T. M. Houlihan continued his interdisciplinary research efforts in studying the turbulent transfer processes of momentum, heat, and specific humidity in the marine environment, particularly in fog regimes. A large amount of shipboard experimental data have been obtained and analyzed.

ENERGY CONVERSION

A recent experimental program has been initiated by Professors D. Salinas and R. H. Nunn to understand the thermal-fluid operating principles of the Fluidyne heat engine. A model engine has been

constructed and instrumented, and a simplified computer program has been developed to predict the engine performance. Possible applications include activating and controlling pneumatic relays, monitoring nuclear reactors, and providing irrigation pumping in remote areas.

LASER TECHNOLOGY

Compressible flow over a laser turret aboard an aircraft causes phase distortion in the laser beam. Professor A. E. Fuhs has completed a study of the laser beam aberrations caused by the inviscid flow field. Both subsonic and supersonic flow regions were investigated. In addition, an investigation of ways to minimize the adverse effects of boundary layer or shear layer turbulence on laser beam propagation has been completed.

Currently, Professor Fuhs is studying beam quality from excimer lasers which operate in the UV and VUV wavelength region. As laser wavelength becomes smaller, the allowable variations in index of refraction become smaller. The dependence of index of refraction on populations, species concentrations, oscillator strengths, etc. is being calculated for typical excimer laser gas mixtures. The waves associated with e-beam power deposition, quantum inefficiency, anode and cathode voltage drops, etc. are being modeled in two spatial and time dimensions, and the index of refraction arising from the baseline flow is being analyzed.

MARINE PROPULSION CONTROLS

Professor T. M. Houlihan has continued his efforts to develop this discipline within the M.E. Department. Course materials in submarine dynamics and control have been added to the presentations in advanced control design. Likewise, new simulation codings involving the LM2500 gas turbine engine and control systems have been developed.

Research involving steam plant modeling and controls has continued. One study produced a model of the LHA boiler and the existent pneumatic control system. The second study featured the application of an optimal integral control design to a "1200 psi" D-type marine boiler. Future studies under the guidance of Professor Houlihan will feature the application of optimization codings to submarine hydraulic control systems.

Further specification of the proposed shipboard automation laboratory is imminent. In anticipation of the final configuration, a microcomputer system is to be procured to provide for the application of a multivariable control system to the steam plant simulator.

Title: Lateral Buckling of Nonprismatic Beams

Investigator: John E. Brock, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To develop theoretical methodology and computer implementation for determining lateral buckling parameters for nonprismatic beams having general loading and quite general constraints.

Summary: The general approach is first to solve the uncoupled fourth order equation for bending in the vertical plane using numerical methods; this is a well known problem and the only difficulties relate to the numerical approximation which is used. Then the results from this first problem are inputs to a coupled lateral-bending torsion problem. The bending problem is of fourth order and the torsion problem is either of first order (if warping rigidity is included in the analysis). A target function is assumed. By manifold numerical integrations and other manipulations, a new version of the target function is obtained. In the process ten unknown scalars are introduced. Eight constraint conditions and two normalizing conditions furnish ten equations which are linear and homogeneous in these ten unknowns but which are quadratic in the unknown and desired loading parameter. This leads to a twentieth order linear eigenproblem most of the eigenvalues of which are zero or infinite. The "QZ" algorithm is used to solve this system. The proper eigenvalue is selected and the corresponding eigenvector contains the previously unknown scalars. An improved target function is constructed and the process is repeated until there is convergence.

Computer programs for both cases (with and without warping rigidity) have been constructed and have passed a series of tests, although further proof of validity is called for. A simplified computer program has been prepared for a less general case. The few results in the literature have been checked and some errors therein have been noted.

Publications:

J. E. Brock, "A Remark on the Lateral Buckling of a Uniform Beam", submitted to Civil Engineering Education.

J. E. Brock, "A General Procedure for Lateral Buckling of Beams", manuscript to be submitted to ASCE Journal for Structures.

Thesis Directed:

Robert E. Brown, "Lateral Buckling of Beams Without Warping Rigidity", Master's Thesis, June 1978.

Title: Improvements in the Predictions of Stresses and Strains in the Finite Element Method

Investigator: Gilles Cantin, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: Stress predictions in the finite element method are unreliable at the free surfaces because boundary conditions are violated. The Loubignac iteration algorithm corrects such deficiencies; however, the process is not completely understood. In this project the algorithm was implemented in the PLISOP system for convergence studies.

Summary: PLISOP and its preprocessors was modified to allow Loubignac iterations as an option. The load generator was also greatly enlarged to allow consistent load vectors corresponding to side pressure and centrifugal loads. The mesh generator was also updated. The codes have been documented and are ready to be released.

Publications: G. Cantin, "An Iterative Algorithm to Build Continuous Stress and Displacement Solutions", 1978, not submitted to a journal.

Theses Directed: Lael Ray Easterling, "Stress Analyses of Ceramic Turbine Blades by Finite Element Method (Part I)", Mechanical Engineer's Thesis, March 1978.

John H. Preisel, Jr., "Stress Analysis of Ceramic Gas Turbine Blades by the Finite Element Method (Part II)", Master's Thesis, March 1978.

Title: Self Filtering Infrared Detector for Missile Seekers

Investigators: Richard Fantauzzo, LCDR, USN, Allen E. Fuhs, Distinguished Professor of Aeronautics and Mechanical Engineering, and Richard B. Schooler, Naval Surface Weapons Center, White Oak Laboratory

Sponsor: Air Force Weapons Laboratory, Kirkland AFB, New Mexico, Code ALO

Objective: To determine if a new technology is feasible for future IR detection devices.

Summary: For a particular threat spectrum, design and fabricate a self-filtering IR detection device. The method is epitaxial film growth by vacuum deposition of composition-tuned lead chalcogenides to form a filter and detector layer on barium fluoride substrates. To utilize pure lead to create a Schottsky Barrier across the P-N function. Gold ohmic contacts complete the device. To test the device and compare performance to commercial indium antimonide devices. This phase of the project completed. Spectral response was measured and found to be as predicted. Quantum efficiency was less than predicted.

Thesis Directed: Richard A. Fantauzzo, "Advanced Infrared Detector for Future Missile Systems", Master's Thesis, to be published December 1978.

Title: Melting of Ice Subjected to Turbulent Flow of Sea Water

Principal

Investigators: Allen E. Fuhs, Distinguished Professor of Aeronautics and Mechanical Engineering; Russel Stolfi, Associate Professor of National Security Affairs

Associate

Investigators: Warren W. Denner, Associate Professor of Oceanography; Peter Wang, Associate Professor of Mathematics; Robert Bourke, Associate Professor of Oceanography; LT William Clifford, USN, Graduate Student in Naval Engineering; LT Reginald Erman, USN, Graduate Student in Naval Engineering; Dr. Owen Griffin, Naval Research Laboratory

Sponsor: Foundation Research Program (6.1)

Objective: To determine the rate of regression of fresh-water ice subjected to turbulent flow of sea water. Further, to develop an analytical model which allows prediction of the ice melting rate and heat transfer rates.

Summary:

Large blocks of ice with dimensions 16 x 4 x 2 feet are frozen. The ice blocks are instrumented with thermocouples to measure gradients in the thermal boundary layer and in the ice. The blocks are towed at speeds ranging from 0.7 to 1.2 knots. Weights are obtained before and after towing. Measurements are made of the dimensions of the ice block before and after towing.

As of 30 September 1978, seven blocks of ice have been towed in Monterey Bay. Nusselt numbers for heat transfer have been obtained. The regression rate has been correlated using the computer code of Dr. Owen Griffin. Ice ripples have been observed and measured. The observations of ice ripples correlate well

with existing theories. Temperatures in the base flow region have been determined. A thermal boundary layer profile has been obtained. The heat transfer equations have been solved for the temperature profile within the ice. Agreement between theory and experiment is excellent.

**Conference
Presentation:**

Allen E. Fuhs, Warren W. Denner, Matthew Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert H. Bourke, and Peter D. C. Wang, "Self Propelled Iceberg". Paper presented by Allen E. Fuhs at the First International Conference on Iceberg Utilization for Fresh Water Production, weather modification and Other Applications, Ames, Iowa, October 2-6, 1977.

Publications:

Allen E. Fuhs, Warren W. Denner, Matthew D. Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert H. Bourke, and Peter C. C. Wang, "Self Propelled Iceberg". Paper published in Proceedings of the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977.

Theses Directed:

William F. Clifford, "Determination of Heat Transfer Rates for Icebergs", Master's Thesis, to be published in March 1979.

Reginald J. Erman, "Determination of Heat Transfer Rates for Icebergs", Master's Thesis, to be published in March 1979.

Title: Holographic Nondestructive Test NDT

Investigators: Allen E. Fuhs, Distinguished Professor of Aeronautics and Mechanical Engineering; LCDR Paul Huber; LT Phillip P. Hoffman

Sponsor: Foundation Research Program (6.1)

Objective: To determine the suitability of holographic nondestructive test as a means of locating weld flaws in piping.

Summary: Real time holography is used to obtain fringe patterns. Fringe patterns are interpreted in terms of surface displacement. Flaws in piping welds have anomalous surface displacements. To check sensitivity, a finite element computer code is used to predict surface displacement. Pipes with manufactured cracks are test specimens.

The holography system has been assembled. Holograms have been made. Test specimens have been assembled including the following: stainless steel piping with manufactured cracks for correlation with finite element computer code, reject piping from Mare Island Naval Shipyard, and aircraft components with known fatigue cracks obtained from NARF, Alameda. The finite element computer code is complete.

Real time holograms were made of vibrating plates with and without flaws. Very small cuts or holes cause very significant change in resonant frequency and mode shapes. The sensitivity resonant frequency has suggested use of heterodyne laser radar to detect microdoppler motions (vibration).

Publication: A. E. Fuhs, "Comment on 'Extensions of Dual-Plate Holography Interferometry,'" AIAA Journal, 16, 3 (March, 1978), p. 287.

Theses Directed:

Paul M. Huber, "Holographic Non-destructive Test", Master's Thesis, March 1978.

Phillip P. Hoffman, "Vibration Analysis and Nondestructural Testing Using Holographic Techniques", Master's Thesis, September 1978.

Title: Shaped Charges for Neutralization of Buried Mines

Investigators: Allen E. Fuhs, Distinguished Professor of Aeronautics and Mechanical Engineering; Richard Louis Funk, Jr., Lawrence M. Kryske, and Dana L. Vugteveen, Lieutenants, USN

Sponsor: Explosive Ordnance Disposal Facility, Indian Head, Maryland, Edward Rice

Objective: To develop a technique to neutralize buried mines. The technique is to be used by EOD officers and crew.

Summary: Mines may be buried at depths from a few inches to 6-8 feet. The buried mines are detected and located by magnetic means. Error in location may be comparable to buried depth. Some means of placing an explosive charge near the mine is required. A shaped charge can open a large hole through which a charge can be rammed.

Two series of charges was designed, built, and tested. One series of charges consisted of a 2-inch diameter shaped charge with 1/2 lb HE located on top of a cylinder containing liquid explosive. The cylinder had a coaxial tube which allowed passage of the metal jet from the shaped charge. It was found that the liquid explosive spray lined the hole; it was also found that the cylinder for the liquid explosive spray lined the hole; it was also found that the cylinder for the liquid explosive was rammed down the hole. As a result of these early tests, a series of tests is being planned using solid explosive located below the shaped charge. A time delay detonator will be used for the solid explosive. The second series of shaped charges used solid explosive could be injected into sand at a depth of 53 inches using a 12/1b HE. Measurements were made of the penetration velocity of the metal jet and velocity of the solid explosive. X-ray diagnostics (300 kV and 600 kV) were at EODF, Indian Head.

Theses Directed:

Lawrence Michael Kryske, "Terradynamically Assisted Shaped Charge Follow-Through Weapon for Mine Neutralization Applications," Master's Thesis, December, 1978.

Dana Lyle Vugteveen, "Terradynamically Assisted Shaped Charge Follow-Through Weapon for Mine Neutralization Applications," Master's Thesis, December, 1978.

Title: Aero-optics; Boundary Layer Control for Laser Beam Propagation

Investigator: Allen E. Fuhs, Distinguished Professor of Aeronautics and Mechanical Engineering

Sponsor: Code ALO; Air Force Weapons Laboratory; Kirtland Air Force Base, New Mexico 87117

Objective: To determine the degradation of laser propagation due to turbulent boundary layer and turbulent shear layers; propagation wavelength is in the visible or near UV.

Summary: For lasers mounted on aircraft, the beam must traverse a turbulent boundary layer or a turbulent shear layer to exit from the aircraft. For long or medium IR, the effects are not serious. However, in the visible or near UV, the beam quality can be degraded seriously.

Publications: Progress Reports to the Air Force Weapons Laboratory.

Title: Land Contouring to Optimize Wind Power

Investigators: Allen E. Fuhs, Professor of Aeronautics; G. N. Vanderplaats, National Aeronautics and Space Administration, Ames; Susan E. Fuhs, California Institute of Technology.

Sponsor: Unsponsored

Objective: Certain locations on a hill have higher local wind velocity than the freestream value. The augmentation of wind power depends on the shape of the hill. An optimum shape for the hill provides maximum wind power.

Summary: Optimum hill shapes were determined for several different constraints. Knowledge of the optimum shape is valuable for two reasons. First, the site selection is aided if the best contour is known; near optimum shape may occur naturally. Second, for a given site, the excavation and fill necessary to achieve optimum shape can be determined. Four cases were studied with wind power augmentation ranging from 156 to 311 per cent.

Publication: S. E. Fuhs, G. N. Vanderplaats, and A. E. Fuhs, "Land Contouring to Optimize Wind Power," AIAA No. 78-279. Accepted for publication in Journal of Energy.

Conference Presentation: A. E. Fuhs, Susan E. Fuhs, and G. N. Vanderplaats, "Land Contouring to Optimize Wind Power," presented at AIAA 16th Aerospace Sciences Meeting, Huntsville, Alabama, January 1978.

Title: Marine Propulsion Control Analysis

Investigator: T. M. Houlihan, Associate Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: Apply multivariable control analyses to the design of a boiler control system.

Summary: An integral output controller was developed for small load changes to a Foster Wheeler ESD boiler. The closed loop responses for both a full (10th) and reduced (7th) order model were determined.

Thesis Directed: M. Miller, "Multivariable Control of a Marine Boiler", Mechanical Engineer's Thesis, September 1978.

Title: Study of Digital Electronic Automatic Combustion Controls

Investigator: T. M. Houlihan, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command, PMS-301

Objective: Application of Modern Control Analyses to Naval Boiler Systems.

Summary: The states variable model of a Foster Wheeler ESD boiler was developed. Open loop responses were simulated using CSMP computer algorithms.

Thesis Directed: C. Senanikrom, "State Variable Analysis of a Boiler System", Master's Thesis, March 1978.

Title: Simulation of LHA Propulsion System

Investigator: T. M. Houlihan, Associate Professor
of Mechanical Engineering

Sponsor: Naval Ship Engineering Center, 61
40C

Objective: Computer simulation of LHA Boiler
System.

Summary: A comprehensive model of the CE boiler
aboard the USS Tarawa was developed.
The present control system was also
modelled. Additionally, a proposed
control system model was developed.
Simulations of system response were
initiated.

Thesis Directed: W. Fini, "Model of a Naval Boiler",
Mechanical Engineer's Thesis, September
1978.

Title: Hot Wire Measurement at San Nicolas Island

Investigator: Thomas Houlihan, Associate Professor of Mechanical Engineering

Sponsor: Naval Research Laboratory

Objective: Correlation of Atmospheric Refraction Data.

Summary: Associate Professor T. M. Houlihan was a member of an interdisciplinary NPS team that participated in a joint exercise with NRL and PMTC personnel involved in laser propagation measurements at San Nicolas Island. The NPS team measured turbulent wind velocity and temperature parameters as well as aerosol particle concentrations in conjunction with laser scintillation and extinction measurements. Measurements were performed both aboard the NPS research vessel ACANIA as well as on the NRL tower test site at San Nicolas Island. Preliminary data analysis indicates very favorable comparisons between the various agency sets of data. Future exercises will include NPS participation in airborne measurements at the same locale.

Publications: T. M. Houlihan, "Observed Height and Stability Dependence of Turbulent Kinetic Energy Dissipation in the Atmospheric Marine Surface Layer", Technical Report, NPS-63-77-002, December 1978.

Title: Heat Transfer, Heat Exchanger Design, Corrosion and Biofouling Hydrodynamics

Investigator: Matthew Kelleher, Associate Professor of Mechanical Engineering

Sponsor: Department of Energy

Objective: Provide OTE Project Management Support to DoE San Francisco Regional Office

Summary: Task I - SEB support, bidders' conference and proposal review, which will include analysis, evaluation and recommendations on heat transfer, heat exchanger design, corrosion and biofouling, hydrodynamics related to OTEC - 1 and the Power System Development (PSD).
Task II - Advise and assist SAN/SED in the development of a comprehensive project management plan for OTEC-1.
Task III - OTEC technical advisory support.

Title: Inter-Agency Agreement to Provide Project Management Support

Investigator: Matthew Kelleher, Associate Professor of Mechanical Engineering

Sponsor: Department of Energy

Objective: The purpose of the Inter-Agency Agreement is to provide program support to the DOE Ocean Thermal Energy Conversion Program. The nature of the program support would be in providing the services of Dr. Matthew Kelleher as the Project Engineer for the OTEC Power System procurements. In this capacity, Dr. Kelleher would serve as the government's technical representative to the contractors.

Summary: The primary duties under this agreement include:

1. Maintain day-to-day liaison with contractors to provide the communication necessary to assure efficient execution of their commitments.
2. Conduct regular project evaluation and review meetings at specified intervals to identify current and future problems and initiate actions for their resolution.
3. Maintain communications with Program Manager's Office regarding problem areas and project status.
4. Provide technical direction as necessary to accomplish project objectives.
5. Conduct Design Review Meetings at specified times.
6. Review and evaluate all reports submitted by contractors.

In addition, Dr. Kelleher will serve to coordinate the flow of information to the contractors from the various technology research and development programs currently being undertaken at Argonne National Laboratory and Oak Ridge National

Laboratory. He would also be available to lend technical assistance to the DoE San Francisco Regional Office in their OTEC procurement efforts.

Department of Energy

Sponsor:

Objective:

The purpose of the Inter-Agency Agreement is to provide program support to the OTEC Ocean Thermal Energy Conversion Program. The nature of the program support would be in providing the services of Dr. Nathan Kallisher as the Project Engineer for the OTEC Power System procurements. In this capacity, Dr. Kallisher would serve as the government's technical representative to the contractor.

Summary:

The primary duties under this agreement include:

1. Maintain day-to-day liaison with contractors to provide the communication necessary to assure efficient execution of their commitments.
2. Conduct regular project evaluation and review meetings at specified intervals to identify current and future problems and initiate actions for their resolution.
3. Maintain communications with Program Manager's Office regarding program areas and project status.
4. Provide technical direction as necessary to accomplish project objectives.
5. Conduct Design Review Meetings at specified times.
6. Review and evaluate all reports submitted by contractors.

In addition, Dr. Kallisher will serve to coordinate the flow of information to the contractors from the various technology research and development programs currently being undertaken at Lawrence National Laboratory and Oak Ridge National

- Title:** Secondary Flow in a Curved Rectangular Channel
- Investigator:** Matthew D. Kelleher, Associate Professor of Mechanical Engineering
- Sponsor:** Un-sponsored
- Objective:** Investigate the structure and transition of the secondary flow in a curved channel and the effects of the secondary flow on heat transfer.
- Summary:** The Taylor-Gortler vortex pattern in a curved rectangular channel of high aspect ratio has been examined using hot wire anemometry. Using a two dimensional traversing mechanism, velocity surveys have been made at several radial locations across the channel for several values of Dean number. The velocity measurements show that the periodic secondary motion undergoes a phase shift as the hot wire probe crosses the midplane between the concave and convex walls. The measurements also indicate that secondary flow wave number is constant over the range of Dean numbers examined. Complementary flow visualization photographs of the secondary motion have also been obtained.
- Publications:** M. D. Kelleher (with D. L. Flentie and R. J. McKee), "An Experimental Study of the Secondary Flow in a Curved Rectangular Channel," Journal of Fluids Engineering, accepted for publication.

- Title:** Stability of Pipe Flows of Newtonian and Viscoelastic Fluids Using Chebyshev Expansion Functions
- Investigators:** Matthew D. Kelleher, Associate Professor of Mechanical Engineering, R. J. Hansen, Naval Research Laboratory
- Sponsor:** Un-sponsored
- Objective:** Develop a Chebyshev expansion function method to analyze the hydrodynamic stability of Newtonian and viscoelastic fluids.
- Summary:** The Chebyshev expansion function method developed in the present work has been shown suitable for the analysis of the pipe flow stability of Oldroyd as well as Newtonian fluids. Its accuracy and rate of convergence in the Newtonian case are comparable to the expansion function analysis of Salwen and Grosch (1972). Application of the method to the study of disturbances to the pipe flow of an Oldroyd fluid for α small compared to unity shows that viscoelasticity exerts a slight stabilizing influence for $\alpha=1.0$ and $\alpha=10.0$ and a larger destabilizing influence for $\alpha=0.1$.
- Conference Presentations:** M. D. Kelleher and R. J. Hansen, "Numerical Study of the Hydrodynamic Stability of Pipe Flows of Newtonian and Viscoelastic Fluids by a Chebyshev Expansion Function Method", presented at the International Conference on Numerical Methods in Laminar and Turbulent Flows, University College of Swansea, Swansea, Wales, United Kingdom, July 1978.

Title: Heat Transfer Enhancement in Naval Condensers

Investigator: Paul J. Marto, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: Evaluate current state-of-the-art heat transfer augmentation techniques which can be used in naval condensers to reduce their size, weight, and/or cost.

Summary: A digital computer program titled ORCONI has been used to study the design of naval condensers. Using heat transfer enhancement on both the steam and seawater sides, the design program shows that the condenser volume may be reduced by as much as 30 - 40 percent. Computer codes for the analysis of naval condensers were coupled with a numerical optimization code to provide fully automated design.

Heat transfer data has been gathered for a variety of tubes. Comparison of this data to smooth tube data indicates an increase in the overall heat transfer coefficient of 100 percent. This performance would lead to a decrease in condenser surface area of 40 - 50 percent when compared to a standard, smooth-tube condenser with equal heat load, and pumping power.

Publications: P. J. Marto (with H. T. Search), "A Feasibility Study of Heat Transfer Improvement in Marine Steam Condensers", Technical Report, NPS 69-77-001, December 1977.

Theses Directed: Charles M. Johnson, "Marine Steam Condenser Design Using Numerical Optimization", Mechanical Engineer's Thesis, December 1977.

Larry Sharp, "An Apparatus to Measure Dropwise Condensation Heat Transfer Coefficients of Steam", Master's Thesis, March 1978.

James H. Fenner, "An Experimental Comparison of Enhanced Heat Transfer Condenser Tubing", Master's Thesis, September 1978.

Objective: To evaluate current state-of-the-art heat transfer augmentation techniques which can be used in naval condensers to reduce their size, weight, and/or cost.

Summary: A digital computer program titled KCOND has been used to study the design of naval condensers. Using heat transfer enhancement on both the steam and seawater sides, the design program shows that the condenser volume may be reduced by as much as 40 - 50 percent. Computer codes for the analysis of naval condensers were created with a numerical optimization code to give this fully automated design.

Heat transfer data has been gathered for a variety of tubes. Comparison of this data to smooth tube data indicates an increase in the overall heat transfer coefficient of 100 percent. This performance would lead to a decrease in condenser surface area of 40 - 50 percent when compared to a standard smooth-tube condenser with equal heat load and pumping power.

References: 1. J. H. Fenner (with M. T. Smith), "A Feasibility Study of Heat Transfer Improvement in Marine Steam Condensers," Technical Report, NPS 88-10-01, Naval Postgraduate School, Monterey, CA, Nov 1977.

2. Charles E. Johnson, "Marine Steam Condenser Design Using Numerical Optimization," Naval Postgraduate School's Thesis, December 1977.

3. Larry Shuler, "An Approach to Marine Condenser Condensation Heat Transfer Coefficients of Steam," Master's Thesis, March 1974.

Title: Thermomechanical Processing of Aluminum-Magnesium Alloys Containing High Weight Percentages of Magnesium

Investigator: Terry R. McNelley, Assistant Professor of Materials Science and Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: Development of processing procedures for, and characterization of the mechanical behavior of, Aluminum-Magnesium alloys containing 8 to 14 weight percent Magnesium.

Summary: In the first year of this program with NAVAIR as sponsor, research has focused on alloys containing more than 8% Magnesium (an amount above conventional alloys) and less than 15% Magnesium (the maximum solubility in Aluminum). Prior work had indicated that excellent properties were attainable in alloys containing still more Mg, but that processing is exceedingly difficult. With less than 15% Mg, an alloy can be solution treated prior to warm rolling at a temperature above the solvus. The basic process consists of solution treating an alloy, cooling to room temperature, reheating to a temperature below the solvus and warm rolling. In a 10% Mg alloy, this processing results in a material of 50 KSI yield strength, 64 KSI ultimate tensile strength, with 14% elongation to fracture. A variation on the basic process is to cold work prior to warm working; this raises the yield and ultimate tensile strengths to 57.5 KSI and 68.3 KSI. This last material may be further cold-worked to yield and ultimate tensile strengths of 79 KSI and 88 KSI, respectively, with 5% elongation still remaining. These recent results are most exciting in that these strengths equal or exceed those of conventional Aluminum-based alloys. In addition, the Mg containing alloys of this research are lower in mass density.

Publications:

T. R. McNelley, "Thermomechanical Processing of Aluminum - Magnesium Alloys: Ambient Temperature Mechanical Properties", First Annual Report to NAVAIR, in preparation.

Conference Presentation:

T. R. McNelley and F. G. Ness, "Microstructure-Mechanical Property Relationships in an Aluminum - Magnesium Alloy", presented at the 107th Annual Meeting of TMS-AIME, Denver, Colorado, February 1978.

Theses Directed:

T. L. Glover, "Effects of Thermo-Mechanical Processing on Aluminum-Magnesium Alloys Containing High Weight Percentage Magnesium", Master's Thesis, December 1977.

C. P. Bungay, "Microstructural Response of Aluminum-Magnesium Alloys to Thermomechanical Processing", Master's Thesis, December 1978.

M. R. Grandon, "Thermomechanical Processing of Aluminum-Magnesium Alloys: Ambient Temperature Mechanical Properties", expected completion March 1979.

Title: Ballistic Characteristics of Thermo-mechanically-Processed Ultra-High Carbon Steels

Investigator: Terry R. McNelley, Assistant Professor of Materials Science and Mechanical Engineering

Sponsor: Ballistics Research Laboratory (BRL)

Objective: Development of processing procedures for Ultra-High Carbon Steels and testing of such steels for possible application as armor materials.

Summary: This research program has demonstrated that thermomechanically-processed Ultra-High Carbon Steels (UHCS) have terminal ballistic characteristics which equal or exceed those of several conventional armor steels. In the past year, funding was obtained from BRL to acquire and process a wide range of UHCS compositions for detailed evaluation of the mechanical and ballistic properties of these steels with a view toward application of these steels as armor materials. In addition, research has also been pursued on a prototype UHCS material which is essentially an AISI type 52100 bearing steel subjected to a thermomechanical processing treatment yielding a fine, spheroidized and particulate cementite dispersed in a fine-grained ferrite matrix. It has been shown that this steel is ballistically superior to several conventional armors against fragment simulating projectiles and that an important factor is the absence of adiabatic shear band formation during ballistic impact. It is believed that this results from the fine microstructure and processing that produced the microstructure. Research is continuing to further examine those characteristics which control ballistic behavior in these steels. Joint efforts with Stanford Research Institute and Stanford University have been undertaken to produce dual hardness laminates of UHCS with low-carbon steels. Results indicate that these laminates have still better ballistic behavior than monolithic UHCS material.

Publications:

T. R. McNelley, R. R. Martin and J. W. Phillips, "Ballistic, Mechanical and Shear Band Formation Characteristics of Thermomechanically Processed Ultra-High Carbon Steels", in preparation for the Ballistics Research Laboratory.

T. R. McNelley, "Ballistic Limit Determination for Thermomechanically-Processed Ultra-High Carbon Steel and Ultra-High Carbon Steel Laminates", Project Report, NPS 69-78-020PR, also submitted to Stanford Research Institute, December 1978.

Theses Directed:

R. R. Martin and J. W. Phillips, "Ballistic, Mechanical and Shear Band Foundation Characteristics of Thermomechanically-Processed Ultra-High Carbon Steels", Master's Thesis, December 1978.

D. Rowe (with D. R. Hamilton), "The Microstructural, Mechanical and Ballistic Characteristics of Ultra-High Carbon Steel", Master's Thesis, December 1977.

D. R. Hamilton (with D. Rowe), "The Microstructural, Mechanical and Ballistic Characteristics of Ultra-High Carbon Steel", Master's Thesis, December 1977.

Title: Effects of Multiple Weld Repairs on Aluminum Alloy 5083-0

Investigator: Terry R. McNelley, Assistant Professor of Materials Science and Mechanical Engineering

Sponsor: United States Coast Guard (USCG), Merchant Marine Technical

Objectives: Simulation of multiple weld repairs by repeated re-welding of 5083-0 Aluminum followed by mechanical, physical and metallographic characterization of multiple weld repair effects.

Summary: The effects of multiple weld repairs on 5083-0 aluminum, used in the primary containment systems for Liquefied Natural Gas (LNG) Tankships, were studied. Changes in micro-structure, mechanical properties and stress-corrosion cracking susceptibility as a function of number of weld repairs were carefully characterized. Coarsening of insoluble precipitates in the heat affected zone was noted and the extent of the heat affected zone increased as number of weld repairs increased. Nonetheless, there was little effect on strength, ductility. Impact, fracture toughness and fatigue characteristics were not included in this effort but will be included in future studies in this area.

Publications: T. R. McNelley and G. R. Speight, "Effects of Multiple Weld Repairs in Aluminum Alloy 5083-0", in preparation.

Thesis Directed: G. R. Speight, "The Effects of Multiple Weld Repairs on the Aluminum Alloy 5083-0", Master's Thesis, September 1978.

Title: Finite Element Analysis of Cavitation

Investigator: R. E. Newton, Professor of Mechanical Engineering

Sponsor: Defense Nuclear Agency

Objective: To include cavitation effects of fluid/structure interaction by modifying the conventional finite element model of the fluid field. This is a continuing program.

Summary: Three separate formulations, using particle displacement, displacement potential, or velocity potential as dependent variable, were shown to be feasible. Using each of the first two of these, excellent agreement with a benchmark solution based on the method of characteristics was demonstrated. Preliminary investigations of problems with axisymmetric geometry were carried out.

Publication: R. E. Newton, "Effects of Cavitation on Underwater Shock Loading - Part I." Technical Report, NPS 69-78-013, July 1978.

Title: Advanced Methods in Computational Thermofluid Dynamics

Investigator: R. H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To install, debug, and operate the family of programs in the CHAMPION series developed at Imperial College, London.

Summary: The computational code titled 2/E/Fix was procured and installed. Several test cases were successfully run for both laminar and turbulent flows with heat transfer (pipe flow, sudden enlargement, coaxial streams, cavity flow). Work was begun to adapt the code to more-complicated geometries. Input/output coding was developed for comparison with available (NPS) data on turbulent coaxial flows.

Publications: Report in progress.

Title: Energy Conversion - Fluidyne

Investigators: R. H. Nunn and D. Salinas, Associate Professors of Mechanical Engineering

Sponsor: Harry Diamond Laboratories, DRxDO-OCA

Objective: To install and instrument a model Fluidyne engine. To evaluate existing performance prediction models for the Fluidyne engine.

Summary: The laboratory model has been built and put into operation. Experiments have been conducted to test for the importance of various gas cavity parameters (volume, temperature) on engine performance. A new analytical model has been developed to extend the analytical capabilities beyond the small perturbation regime.

Thesis Directed: David C. Mosby, "The Fluidyne Heat Engine", Master's Thesis, September 1978.

Title: Integrated Cost/Performance Analysis of Marine Propulsion Systems

Investigators: R. H. Nunn and M. D. Kelleher, Associate Professors of Mechanical Engineering

Sponsor: Naval Sea Systems Command, Code 0331, J. W. Murrin

Objective: Develop optimization techniques for design and analysis of propulsion systems and components.

Summary: Design optimization code was utilized to examine the performance and improvement potential of a simple heat exchanger. Optimization techniques were developed and made operable on local computer system.

Publications: Informal interview progress report to sponsor, 1 November 1977.

Title: Analog Simulation of the LHA Steam Generating Plant

Investigators: R. H. Nunn, T. M. Houlihan, Associate Professors of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: Generate simulation capability for LHA Steam Plant. Compare with NAVSEC modelling philosophy and identify regions of systems modelling and simulation that are in need of improvement.

Summary: The simulation capability has been developed and is available for use in on-going propulsion control system research. Various improvements have been recommended and have been the subject of discussion with NAVSEC and sponsor personnel.

Title: Gas Turbine Exhaust Stack Eductor Systems

Investigator: Paul F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command, Code 0331G, C. L. Miller

Objective: To determine the performance of scale models of gas turbine exhaust gas stack eductor systems, and to recommend criteria for the design of gas turbine exhaust gas stack eductor systems for naval ships.

This is a continuing research program, begun in Summer 1976.

Summary: Cold flow tests of a four nozzle eductor system were conducted to evaluate the system's performance with the following geometric modifications: changing the area ratio of the mixing stack to primary flow nozzles; adding a solid diffuser to the exit of the mixing stack; adding film cooling ports along the length of the mixing stack; and combining several of these variations.

Hot flow model tests were conducted on model previously tested on the cold-flow system. The data was found to be effectively correlated by the correlation parameters previously developed.

Eductor testing will continue through FY 79.

Theses Directed: R. J. Lemke and C. P. Staehli, "Performance of Multiple Nozzle Eductor Systems with Several Geometric Configurations", Master's Thesis, September 1978.

D. R. Welch, "Hot Flow Testing of Multiple Nozzle Exhaust Eductor Systems", Mechanical Engineer's Thesis, September 1978.

Title: Energy Conversion - Fluidyne

Investigators: David Salinas, Associate Professor of Mechanical Engineering and Robert H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To install and instrument a model Fluidyne engine. To evaluate existing performance prediction models for the Fluidyne engine.

Summary: The existing theoretical models (two) have been carefully reviewed and improvements and corrections have been made. A technically coherent (but still vastly simplified) model has been developed based upon this review. A series of feasible designs for the experimental setup have been created and materials and equipment have been ordered for the construction of the experimental apparatus. A rough-cut experimental device has been operated.

Thesis Directed: David C. Mosby, "The Fluidyne Heat Engine", Master's Thesis, September 1978

Title: Advanced Composites Fire Response Program

Investigator: David Salinas, Associate Professor of Mechanical Engineering

Sponsor: Naval Weapons Center, China Lake

Objective: To develop a comprehensive analytical model of a composite plate in a fire environment and to provide a program for the solution of the problem.

Summary: The task includes four major fields of investigation (a) the determination of the thermochemistry of the ablation process, (b) the determination of the properties of composites as a function of temperature, (c) the determination of temperature of a composite in a fire environment, and (d) the determination of the strength of composites due to loading in a fire environment. The approach is to obtain (or develop, if necessary) analytical numerical methods for solution of each of the above tasks.

- Title:** Vortex-Induced Cable Strumming
- Investigator:** T. Sarpkaya, Professor of Mechanical Engineering
- Sponsor:** Civil Engineering Laboratory, Port Hueneme, CA
- Objective:** Continued development of theory and methods of prediction for cable strumming.
- Summary:** Elastic structures of one or more degrees of freedom can extract energy from the flow about them and can develop catastrophic flow-induced oscillations. The understanding of this energy transfer is of paramount importance if one is either to eliminate or minimize it or to design the elastic structure in such a manner that it can withstand the oscillations under contemplated loads induced by the environmental conditions.
- The discrete vortex model has been applied to the determination of the fluid forces acting on the cylinders. The model will be extended to the prediction of the self-excited oscillations of cylinders. In addition, experiments with sand-roughened cylinders will be carried out in the range of Reynolds numbers encountered under practical conditions to assess the influence of roughness on the amplitude of forces and oscillations. The preliminary results have shown that roughness may play a significant role on hydroelastic oscillations.
- Publications:** Sarpkaya, T., "Fluid Forces on Oscillating Cylinders," Journal of the Waterway, Port, Coastal and Ocean Division of ASCE, Vol. 104, No. WW4, August 1978, pp: 275-290.
- Sarpkaya, T., "Transverse Oscillations of a Circular Cylinder in

Uniform Flow, Part-I," Technical Report,
NPS-69SL77071, December 1977.

Thesis Directed:

Demirbilek, Z., "Transverse Oscilla-
tions of a Circular Cylinder in Uni-
form Flow," Mechanical Engineer's Thesis,
September 1977.

Shoaff, R. L., "A Discrete Vortex
Analysis of Flow About Stationary
and Transversely Oscillating Circu-
lar Cylinders," Ph.D. Thesis,
December 1978.

Title: Fluidic Concepts Development

Investigator: T. Sarpkaya, Professor of Mechanical Engineering

Sponsor: Naval Air Development Center, Warminster, PA.

Objective: Fluidic concepts development and project evaluation in response to the needs of NAVAIRDEVCEN. Specifically, analyze data and review reports generated under the contracts concerning the development of flexible duct valve for use in ramjet fuel control system.

Summary: A review of existing ramjet engine technology indicates the need for a low cost fuel control valve in the flow range of 10,000 to 15,000 pounds per hour. The feasibility of a flex-duct valve concept for fuel control applications where fuel flow requirements have not exceeded 500 pounds per hour has been demonstrated. For these applications, it has been shown that a high-performance valve can be produced at relatively low cost. For the research investigated herein the existing concepts will be utilized as the basis for the development of design criteria for larger valves for ramjet fuel controls and similar high fluid flow applications. A model has been constructed and the experiments will be carried out during the course of the investigation.

Title: Prediction of Forces and Moments at High Alpha

Investigator: T. Sarpkaya, Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command, Washington, D. C.

Objective: The attainment of an understanding of the separated flow about missiles at high angles of attack and the determination of the in-plane and out-of-plane forces acting on the body through the use of the potential flow methods and experiments.

Summary: A unique computer model for the evolution of the time-dependent asymmetric flow about a cylinder has been developed. The model calculates the boundary layer, the separation points, the rate of vorticity shed, the position of vortices, the pressure and velocity distributions, and the lift and drag forces acting on the body. At each step, the entire vortex system is rediscrretized to eliminate the shear-layer instability. The effect of the method of rediscrretization, the method of the introduction of nascent vortices and initial disturbances, the concentration of vortices, etc., have been carefully examined. The computer program is as much free from arbitrary parameters as mathematically and physically possible. Experiments have been conducted in a vertical water tunnel with impulsively-started flow about cylinders. The results obtained from the numerical model are found to be in good agreement with those obtained experimentally. A motion picture has been made to illustrate the evolution of the wake and the comparison between the measured and calculated forces.

Publications: Sarpkaya, T. and Shoaff, R. L., "A Discrete-Vortex Analysis of Flow

About Stationary and Transversely Oscillating Circular Cylinders,"
Technical Report, NPS 69SL79011,
January 1979.

Conference

Presentations:

Sarpkaya, T. and Shoaff, R. L., "An Inviscid Model of Two Dimensional Vortex Shedding for Transient and Asymptotically-Steady Separated Flow Over a Cylinder," AIAA Paper No. 79-0281, 17th Aerospace Sciences Meeting of the American Institute of Aeronautics and Astronautics, New Orleans, La., January 15-17, 1979.

- Title:** Hydroelastic Oscillations in Harmonic Flow
- Investigators:** T. Sarpkaya, Professor of Mechanical Engineering
- Sponsor:** National Science Foundation
- Objective:** Continued development of analytical and experimental methods for the understanding and prediction of self-excited oscillations in harmonically oscillating flows.
- Summary:** The dynamic cross-flow response of elastically mounted smooth and rough cylinders in a sinusoidally oscillating flow has been studied both theoretically and experimentally. The experiments were conducted in a large U-shaped water tunnel. The results have been expressed in terms of lift coefficients, relative displacement, Reynolds number, Strouhal number, relative roughness, and a mass parameter characterizing the natural frequency of the system.
- A theoretical analysis has been carried out by expressing the transverse force as a sum of its Fourier components. The instantaneous values of the displacement have been predicted through the use of Duhamel's superposition integral. Furthermore, the discrete vortex model has been refined through the rediscrretization of vorticity along the shear layers and applied to the prediction of the cross-flow oscillations of the cylinder.
- Publications:** Sarpkaya, T., "In-Line and Transverse Forces on Cylinders in Oscillatory Flow at High Reynolds Numbers," Journal of Ship Research, Vol. 21, No. 4, December 1977, pp 200-216.
- Sarpkaya, T., "The Hydrodynamic Resistance of Roughened Cylinders

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Theses Directed:

D. J. Klinkhamer, "Self-Excited Oscillations of a Smooth Circular Cylinder in Harmonic Flow", Master's Thesis, March 1978.

R. L. Shoaff, "A Discrete Vortex Analysis of Flow About Stationary and Transversely Oscillating Circular Cylinders", Ph.D. Thesis, December 1978.

Title: Missile System Reliability Program

Investigator: W. M. Woods, Dean of Educational Development

Sponsor: Strategic Systems Project Office, Washington, D. C.

Objective: Provide mathematical and reliability technical support on TRIDENT Program.

Summary: Several technical papers were written in response to specific assignments pertaining to detection of degradation of missile reliability and evaluation of Lockheed Missile and Space Company documents. Two reliability growth models that offer potential for utilization in the Fleet Ballistic Missile Weapons Program were evaluated via Monte Carlo simulation. Numerous trips were made to LMSC Sunnyvale, California to participate in meetings.

Thesis Directed: R. O. Neal, "An Evaluation of Three Reliability Growth Models", Master's Thesis, June 1978.

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